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# SCIENCE 10

## Module 3

## *Cycling Matter in Living Systems*

Learning Technologies Branch

Alberta EDUCATION

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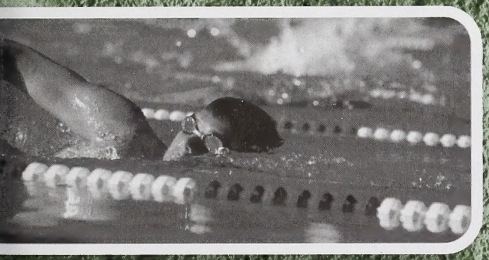
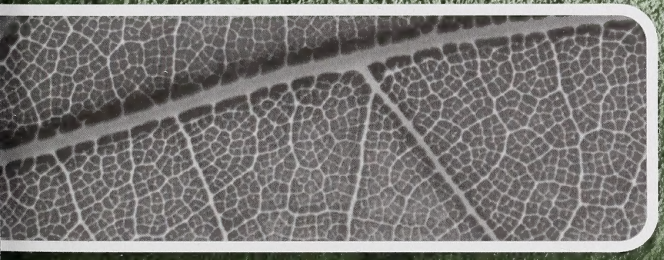
# Science 10

## Module 3

## *Cycling Matter in Living Systems*





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Module 3: Cycling Matter in Living Systems
Student Module Booklet
Learning Technologies Branch
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| Home Instructors | |
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| Other | |

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- Alberta Education, **http://www.education.gov.ab.ca**
- Learning Technologies Branch, **http://www.education.gov.ab.ca/ltb**
- Learning Resources Centre, **http://www.lrc.education.gov.ab.ca**

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*Welcome to*

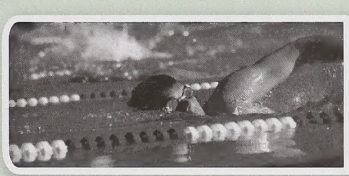
# SCIENCE 10

## Module 3

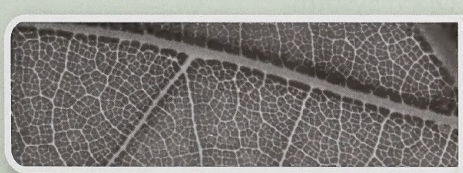
*Module 1 contains general information about the course components, additional resources, icons, assessment, and strategies for completing your work. If you do not have access to Module 1, contact your teacher to obtain this important information.*

**It is recommended that you work through the modules in order (from 1 to 4) because concepts and skills introduced in one module will be reinforced, extended, and applied in later modules.**

**Module 1**
*Energy and Matter in Chemical Change*



**Module 2**
*Energy Flow in Technological Systems*



**Module 3**
*Cycling Matter in Living Systems*

**Module 4**
*Energy Flow in Global Systems*

# Table of Contents

# Module Overview

Did you know that in August of 2004 the BC Centre for Disease Control reported that 18 cases of hamburger disease occurred in the previous month? Hamburger disease is a stomach ailment caused by ingesting E. coli 0157. This specific strain of E. coli bacteria is present in the intestines of cattle and can be transferred to the surface of the meat during butchering. You can come into contact with E. coli 0157 by handling raw hamburger and eating undercooked hamburger. Symptoms include severe abdominal pain and, in some cases, can result in death. Preventing hamburger disease is quite simple actually. You only need to make sure you refrigerate uncooked hamburger and cook hamburger thoroughly.

The ability to detect small organisms and cell structures has led to increased understanding of how cells function and the life processes of cells and multicellular organisms.

In this module you will learn how cell structures and organelles function to carry out the life processes in living systems. You will discover how technological advancements have improved people's understanding of cell structure and function. You will then apply this understanding of life processes at the cellular level to multicellular organisms.

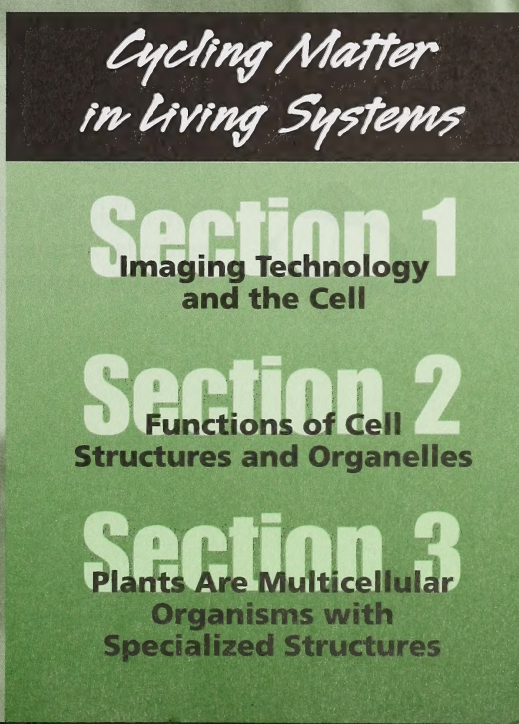
Turn to page 239 of the textbook and read "Focus on the Nature of Science" to see what is ahead in Unit C. Then read "Exploring" on pages 240 and 241 for more information on E. coli and water treatment.

## Assessment

This module, Cycling Matter in Living Systems, has three section assignments. The mark distribution is as follows:

| | |
|---|---|
| **Assignment Booklet 3A** | |
| Section 1 Assignment | 33 marks |
| **Assignment Booklet 3B** | |
| Section 2 Assignment | 41 marks |
| **Assignment Booklet 3C** | |
| Section 3 Assignment | 56 marks |
| **TOTAL** | **130 marks** |

Be sure to check with your teacher if this mark allocation is valid for you. Some teachers may include other reviews and assignments for additional assessment.



# Imaging Technology and the Cell

Modern, high-powered microscopes are used in many areas—such as microbiology to study pathogens; forensic science to analyze fibres, body fluids, and tissues; and metallurgy to locate metal defects. Electron microscopes and imaging technology microscopes are used when even greater magnification or soft tissue imaging is needed.

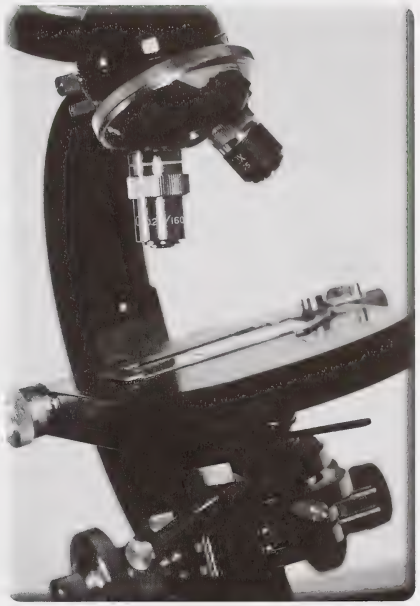
The development of microscope technology over time has led to today's understanding of the cell and cellular processes.

In this section you will study microscopy and the emergence of cell theory. You will trace the development of cell theory and describe how advancements in cell structure and function are a direct result of developments in microscope technology.

Turn to page 242 of the textbook and read the introduction to Unit C 1.0. Pay particular attention to the key concepts and the learning outcomes listed. They provide a quick overview of what you will cover in this section.

# Lesson 1

## A Window on a New World



Have you used a microscope before? Microscopes help you see things that cannot be seen with the naked eye. A basic microscope consists of two lenses (an eyepiece and an objective lens) that can magnify an object several hundred times.

Early microscopes consisted of one, two, or three lenses and a light source. Turn to page 243 of the textbook and read the introductory paragraph of "A Window on a New World." Continue by reading "Early Microscopes and Microscopists" and "Improvements in Lens Technology" on pages 243 and 244. You will gain knowledge about early microscopes and the people who built and/or used them.

1. What ideas about scientific study did Aristotle provide the science community?

2. Who is credited with building the first microscope?

3. What are the three main components of a basic light microscope?

4. What did Robert Hooke discover about the structure of cork?

5. Why was van Leeuwenhoek able to produce single-lens microscopes that were better than the compound microscopes of his day?

Check Check your answers with those on page 16.

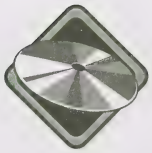
To learn more about the history of the microscope and about the people who built and used them, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Pages 243–244. There you will find a list of informative websites.

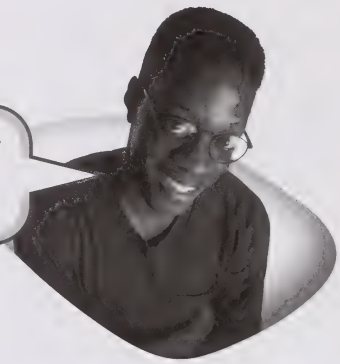
## Parts of a Modern Microscope

You most likely have already used a microscope in previous science courses and are probably familiar with the parts and use of a microscope. However, it's a good idea to review the parts of a microscope.



Insert the Science 10 Multimedia CD into your computer, and view the segments "Introduction: Science 10 Microscopes," "Segment 1: Parts of the Microscope," and "Segment 2: Caring and Storing of Microscopes."

For further review, you may also refer to "The Parts of the Microscope" on page 478 of the textbook.



6. Complete each statement by filling in the blanks with the correct parts of the microscope.

   a. The lens at the upper end of the body tube is called the _____.

   b. The _____ objective lens should be used to locate a specimen on a slide.

   c. The _____ should never be used with the high-power lens.

   d. The _____ holds the three objective lenses.

   e. The microscope should be carried by grasping the _____ with one hand and holding the _____ with the other hand.

   f. The _____ is used to focus the medium- and high-power lenses.

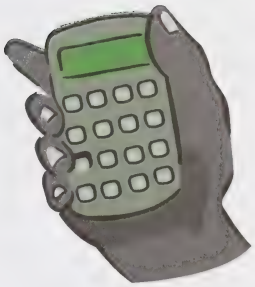
   g. Another name for the eyepiece is _____.


Check your answers with those on page 17.

## Calculating Magnification

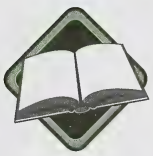
**magnification:** an increase in the apparent size of an object calculated as the product of the magnifying power of the objective lens and the magnifying power of the eyepiece

When using a microscope, it is important to be able to calculate the **magnification** of the lens system and to be able to estimate an object's size using the field of view of the microscope.



To calculate the magnification of a compound microscope, multiply the power of the objective lens by the power of the eyepiece. For example, if the power of the objective lens is 40× and the power of the eyepiece is 10×, the magnification is calculated as follows:

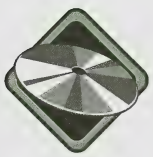
$$\begin{aligned}\text{magnification} &= (\text{power of objective lens})(\text{power of eyepiece}) \\ &= (40)(10)\times \\ &= 400\times\end{aligned}$$



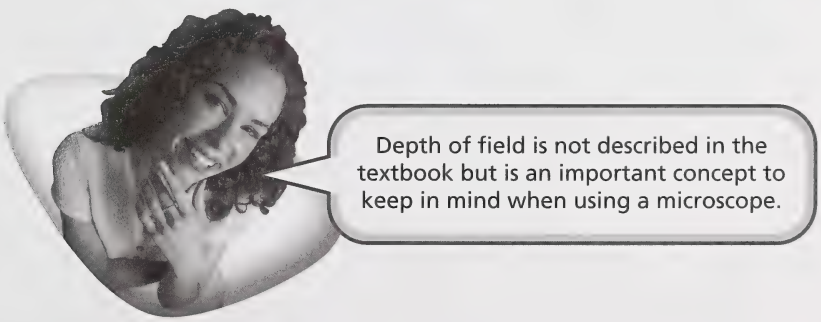
Turn to page 244 of the textbook and read "Skill Practice: Calculating Magnification."

7. Answer questions a. and b. of "Skill Practice: Calculating Magnification."


Check your answers with those on page 17.



Insert the Science 10 Multimedia CD into your computer, and view "Segment 4: Using the Objective Lenses" and "Segment 5: Depth of Field." These segments will provide you with more information on objective lenses, limitations of the powers of objective lenses, field of view, and depth of field.



## Field of View

**field of view:** the area seen under a microscope with a given objective lens

The **field of view** is the area you see when you look through the eyepiece of a microscope. The diameter of the field of view using a low- or medium-power lens can be found by setting a transparent, plastic ruler on the stage of the microscope. The method is described in "Magnification and Field of View" on pages 478 and 479 of the textbook. **Note:** The numbers shown in Figure 8.2 represent millimetres (mm), not centimetres.

You will not see any marks or numbers between or above the long lines representing millimetres when you view a transparent ruler under low power of a microscope. The marks and numbers were added to the diagram on page 479 of the textbook and in Figure C1.6 on page 245 so you can give the measurements for the exercises that follow to the nearest tenth of a millimetre. The following diagram is what you will normally see through a microscope lens when you view a transparent, plastic ruler under low power (40×).

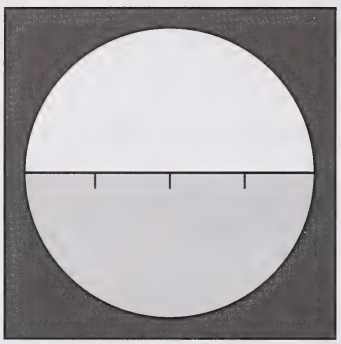


**Figure 1.1:** Field of view under low power

8. Study Example 8.1 on page 479 of the textbook.

   a. What is the diameter of the field of view for the low-power lens in millimetres (mm) and in micrometres (μm)?

   b. What is the diameter of the field of view for the medium-power lens in millimetres (mm) and in micrometres (μm)?

   c. How is the diameter of the field of view in micrometres (μm) obtained for each lens power?

   d. What happens to the diameter of the field of view as the magnification increases?

   e. Calculate the field of view of a 100× high-power lens.


Check your answers with those on page 17.

## Inquiry Lab

# Estimating an Object's Size with the Microscope

Turn to pages 245 and 246 of the textbook and read the entire activity.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Complete the activity as described in steps 1 to 9 of the procedure. **Pay special attention when handling and using the microscope and glass slides.**

9. Copy and complete the table given on page 245 of the textbook. Record your magnification and field diameter for low and high power. The method for calculating the field diameter for the high-power field is given in step 5 of the procedure. Notice that the low-power field diameter is 4.5 mm. The diameter shown in Figure C1.6 might be interpreted as 4.5 cm, since it appears to be centimetres that are shown on the ruler. However, the labelled marks are in millimetres (mm) and the divisions between the numbered marks are in tenths of a millimetre.

10. Review step 6 of the procedure.

    a. Draw a diagram of what you see in the high-power field for the prepared animal or plant slide, and calculate the scale of the drawing.

    b. Estimate the size of the specimen on the prepared slide.

11. Answer the following on page 246 of the textbook.

    a. questions 1 and 2 of "Analyzing and Interpreting"
    b. question 3 of "Forming Conclusions"


Check your answers with those on pages 18 and 19.

## Part B

12. Complete the following table to record your magnification and field diameter for low and high power. The method of calculating the field diameter for the high-power field is given in step 5 of the procedure on page 245 of the textbook. Notice that the low-power field diameter is 4.5 mm. The diameter shown in Figure C1.6 might be interpreted as 4.5 cm as it appears to be centimetres that are shown on the ruler. However, the labelled marks are in millimetres (mm) and the divisions between the numbered marks are tenths of millimetres (mm). The marks and numbers were added by the authors so you can give the measurements for the exercises that follow to the nearest tenth of a millimetre.

| Field | Magnification | Field Diameter (mm) | Field Diameter (µm) |
|---|---|---|---|
| low power | 40× | 4.5 mm | |
| high power | 400× | | |

13. Answer the following on page 246 of the textbook.

    a. questions 1 and 2 of "Analyzing and Interpreting"
    b. question 3 of "Forming Conclusions"


Check your answers with those on page 19.

14. Suppose you measure the low-power field of view with a ruler and it is 2 mm. The high-power magnification is 10 times the low-power magnification.

    a. What is the distance across the field of view under the high-power lens in millimetres (mm)?

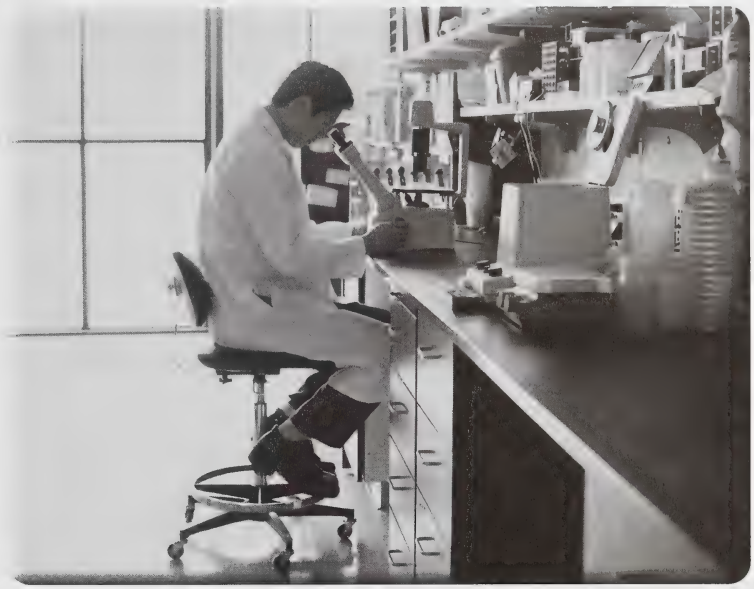
    b. What is the distance across the field of view under the high-power lens in micrometres (µm)?

    c. If the specimen covers three-quarters of the field of view under the high-power lens, what is the length of the specimen in micrometres (µm)?


Check your answers with those on page 19.

## Looking Back

You have now completed the concepts for this lesson. You read about early inventors and the development of the microscope. You observed that microscopes have helped scientists learn about structures too small to see with the naked eye and that the field of view changes with magnification.



15. Answer questions 1, 3, 5, 6, 7, and 8 of "Check and Reflect" on page 246 of the textbook.

Check your answers with those on pages 19 and 20.

Go to pages 1 and 2 of Assignment Booklet 3A and answer questions 1 to 6.

## Glossary

**field of view:** the area seen under a microscope with a given objective lens

**magnification:** an increase in the apparent size of an object calculated as the product of the magnifying power of the objective lens and magnifying power of the eyepiece

## Parts of a Microscope

**base of a microscope:** part of a microscope that holds the body and stage in place

**coarse adjustment knob:** a knob on a microscope used to focus the low-power or medium-power objective lenses

**diaphragm:** a part of a microscope that can be adjusted to allow various amounts of light to pass through the specimen

**eyepiece:** the lens located at the upper end of the body of a microscope; the lens that magnifies the image from the objective lens

**fine adjustment knob:** a knob on a microscope used to focus the high-power objective lens

**objective lenses:** lenses located at the lower end of the body of a microscope; lenses that gather light from the specimen and that magnify and invert the image

**revolving nosepiece:** part of a microscope that holds the objective lenses and allows them to be rotated into position

**stage:** part of a microscope that holds the slide in position for viewing

**stage clips:** parts of a microscope used to hold the slide in position

## Suggested Answers

1. Aristotle followed a pathway of careful observations and record making, followed by reasoning and interpretation. This method of performing scientific observations is still used by the modern scientific community.

2. Hans and Zacharias Janssen are credited with building the first microscope in 1595.

3. The three main components of a basic light microscope are lenses, a body, and a light source.

4. Robert Hooke discovered that cork consists of empty spaces surrounded by a mesh of fibre. He called the empty chambers *cells*.

5. Van Leeuwenhoek was able to produce single-lens microscopes that were better than the compound microscopes of his day because he was a skilled lens builder. Also, the single-lens microscope avoided the problem of blurry images that resulted when light passed through more than one lens.

6. a. The lens at the upper end of the body tube is called the **eyepiece**.

   b. The **low-power** objective lens should be used to locate a specimen on a slide.

   c. The **coarse adjustment knob** should never be used with the high-power lens.

   d. The **revolving nosepiece** holds the three objective lenses.

   e. The microscope should be carried by grasping the **arm** with one hand and holding the **base** with the other hand.

   f. The **fine adjustment knob** is used to focus the medium- and high-power lenses.

   g. Another name for the eyepiece is **ocular**.

7. **Textbook questions a. and b. of "Skill Practice: Calculating Magnification," p. 244**

   a. $\text{magnification} = (\text{power of objective lens})(\text{power of eyepiece})$
   $= (2.5)(10)\times$
   $= 25\times$

   The magnification of this combination of lenses is 25×.

   b. $\text{magnification} = (\text{power of objective lens})(\text{power of eyepiece})$
   $= (100)(10)\times$
   $= 1000\times$

   The magnification of this combination of lenses is 1000×.

8. a. The diameter of the field of view of the low-power lens is 4.5 mm or $4.5\times10^3$ µm.

   b. The diameter of the field of view of the medium-power lens is 1.1 mm or $1.1\times10^3$ µm.

   c. The diameter of the field of view in micrometres (µm) is obtained by multiplying the diameter of the field of view in millimetres (mm) by $10^3$ (or 1000).

   d. The diameter of the field of view decreases as the magnification increases.

   e. $$\frac{\text{HP field diameter}}{\text{LP field diameter}} = \frac{\text{LP magnification}}{\text{HP magnification}}$$
   $$\text{HP field diameter} = \text{LP field diameter}\times\left(\frac{\text{LP magnification}}{\text{HP magnification}}\right)$$
   $$= 4500\ \mu\text{m}\times\left(\frac{4\times}{100\times}\right)$$
   $$= 180\ \mu\text{m or } 1.8\times10^2\ \mu\text{m}$$

9. Answers will vary. A sample answer is given.

| Field | Magnification | Field Diameter (mm) | Field Diameter (μm) |
|---|---|---|---|
| low power | 40×<br>[(4×)(10×)] | 4.5 | 4500 |
| high power | 400×<br>[(40×)(10×)] | 0.45 | 450 |

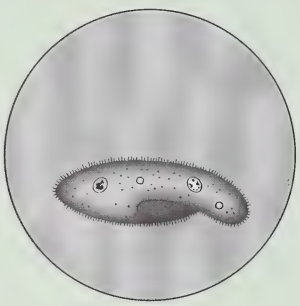
$$\frac{\text{high-power field diameter}}{\text{low-power field diameter}} = \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

$$\text{high-power field diameter} = \text{low-power field diameter} \times \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

$$= 4.5 \text{ mm} \times \frac{40\times}{400\times}$$

$$= 0.45 \text{ mm or } 450 \text{ μm}$$

10. a. Drawings will vary. A sample drawing is given.



Size of field of view in high-power lens = 0.45 mm
Size of circle in drawing = 4.5 cm or 45 mm
Scale of drawing = 45 mm to 0.45 mm, or 100 to 1

b. The size of paramecium specimen is $0.45 \text{ mm} \times \frac{2}{3} = 0.30 \text{ mm}$.

11. a. **Textbook questions 1 and 2 of "Analyzing and Interpreting," p. 246**

1. The magnification is increased 10 times when changing from low power to high power.

2. The field of view decreased by 10 times when you changed from low power to high power.

b. **Textbook question 3 of "Forming Conclusions," p. 246**

3. To estimate the size of an object viewed under the high-power objective lens if the size of the field of view under the low-power lens is known, the following methods can be used:

   - Calculate the field of view of the high-power lens using the following formula:

$$\frac{\text{high-power field diameter}}{\text{low-power field diameter}} = \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

   - Observe how much of the field of view is occupied by the object and estimate the actual size of the object.

12.

| Field | Magnification | Field Diameter (mm) | Field Diameter (μm) |
|---|---|---|---|
| low power | 40× | 4.5 mm | 4500 |
| high power | 400× | 0.45 | 450 |

13. Refer to the answer to question 11.

14. a. $$\text{high-power field of view} = 2 \text{ mm} \times \frac{1}{10}$$
$$= 0.2 \text{ mm}$$

The field of view of the high-power lens is 0.2 mm.

b. $$\text{high-power field of view} = 0.2 \text{ mm} \times \frac{1000 \text{ μm}}{1 \text{ mm}}$$
$$= 200 \text{ μm}$$

The field of view of the high-power lens is 200 μm.

c. $$\text{length of specimen} = 200 \text{ μm} \times \frac{3}{4}$$
$$= 150 \text{ μm}$$

The length of the specimen is 150 μm.

15. a. **Textbook questions 1, 3, 5, 6, 7, and 8 of "Check and Reflect," p. 246**

1. Robert Hooke used a microscope with three lenses, where the specimen was illuminated by a beam of light concentrated by passage through a water-filled flask. Van Leeuwenhoek made single-lens microscopes that were held directly at the eye. His lens was of such a high quality that they produced greater magnifications than compound microscopes of the day.

3. A simple microscope has only one lens; a compound microscope has at least two lenses.

5. Total magnification is calculated by multiplying the power of the objective lens by the power of the eyepiece lens. For example, a microscope has a 40× objective lens and a 10× eyepiece lens. Therefore, the total magnification is

$$\begin{aligned}\text{Total magnification} &= (\text{power of objective lens})(\text{power of eyepiece}) \\ &= (40)(10)\times \\ &= 400\times\end{aligned}$$

6. Use the conversion 1 mm = 1000 μm.

$$\begin{aligned}\frac{x}{1.5\text{ mm}} &= \frac{1000\ \mu\text{m}}{1\text{ mm}} \\ x &= \frac{(1000\ \mu\text{m})(1.5\text{ mm})}{1\text{ mm}} \\ &= 1500\ \mu\text{m}\end{aligned}$$

7. $$\frac{\text{high-power field diameter}}{\text{low-power field diameter}} = \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

$$\text{high-power field diameter} = \text{low-power field diameter} \times \frac{\text{low-power magnification}}{\text{high-power magnification}}$$

$$\begin{aligned}\text{high-power field diameter} &= 1500\ \mu\text{m} \times \frac{10\times}{40\times} \\ &= 375\ \mu\text{m}\end{aligned}$$

The high-power field diameter is 375 μm.

8. The measurement of the structure is 2.5 cm or 25 mm.

$$\begin{aligned}\text{scale} &= 25 : 0.5 \\ &= 50 : 1\end{aligned}$$

The scale of the diagram is 50:1.

## Image Credits

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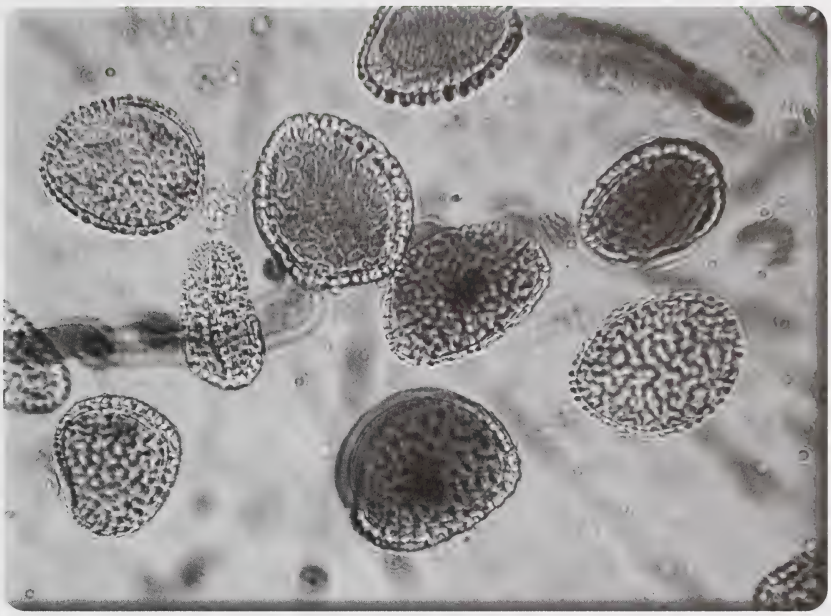
# Lesson 2

## Development of the Cell Theory



**spontaneous generation:** the theory that life could emerge spontaneously from non-living matter

**cell theory:** the theory stating that all living things are made up of cells, the smallest unit of life, and that all cells come from pre-existing cells

The microscope provided the technology to explore the world of microscopic organisms. Before the invention of the microscope, many people believed in **spontaneous generation**—the emergence of life spontaneously from non-living matter. With the invention of the microscope, scientists were able to show many living organisms that could not be seen with the naked eye. The microscope also showed details of cells and, therefore, led to the development of **cell theory**.

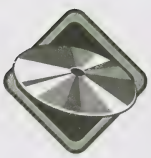
Spontaneous generation thrived until the nineteenth century. In the seventeenth and eighteenth centuries, scientists performed a number of experiments that disproved the theory of spontaneous generation; however, spontaneous generation continued to be accepted.

Turn to pages 247 to 249 of the textbook and read the introductory paragraph of "Development of the Cell Theory" and the information in "Spontaneous Generation."

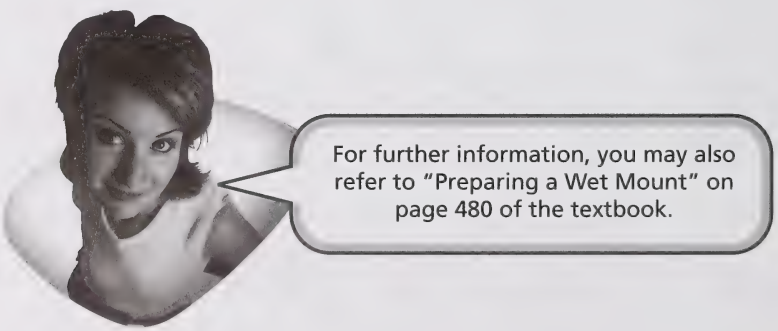
1. Who first proposed the theory of spontaneous generation?
2. How did Francesco Redi try to disprove the theory of spontaneous generation?
3. What was the manipulated variable in Redi's experiment?
4. How did John Needham try to prove that living things could be produced from non-living matter?
5. What did Lazzaro Spallanzani suggest was the cause of the growth in John Needham's flask?
6. How did believers of spontaneous generation try to discredit Spallanzani's ideas?
7. Describe the experiment Louis Pasteur performed to disprove spontaneous generation.
8. What were Pasteur's manipulated and responding variables?

Check your answers with those on page 26.

A microscope can reveal a whole new world of organisms and structures that cannot be seen with the naked eye. Organisms—like amoebas, stentors, and euglena—as well as parts of a cell can be seen with a compound microscope.



The next activity involves preparing a wet mount slide. Before you do this activity, it is a good idea to become more familiar with preparing a wet mount slide. Insert the Science 10 Multimedia CD into your computer, and watch "Segment 3: Preparing a Wet Mount and Observing a Specimen."



# Inquiry Lab

## Examining Pond Water

Turn to pages 250 and 251 of the textbook and read the entire activity. This activity will allow you to become familiar with some of the organisms you can see in pond water using a microscope.

You may refer to the following website to become familiar with various organisms commonly found in pond water.

**http://www.microscopy-uk.net/pond/index.html**

You may also search for information by entering the words *microscopic organisms in pond water* in one of the Internet's search engines or check science reference books at your local library.

9. Name some organisms you think you will find in pond water.


Check your answer with the one on page 26.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

### Part A

Follow the steps outlined in the procedure on page 250. **Pay special attention to the safety precautions mentioned.**

10. Draw a diagram of each organism you see and label it with the part of the container the drop of water came from.

11. Answer the following on page 250 of the textbook.

    a. questions 1 and 2 of "Analyzing and Interpreting"
    b. question 3 of "Forming Conclusions"


Check your answers with those on page 27.

## Part B

Insert the Science 10 Multimedia CD into your computer, and view the segment "Pond Water." Answer the following questions as you view the segment. You may have to stop the segment or go back as you answer the questions.

12. a. What was seen when a drop of water was placed under the low-power lens?

    b. How do the organisms under the medium-power lens compare to those under the low-power lens?

    c. What happened to the organism when Protoslo was used?

    d. What organism was seen in the water taken from the top of the aquarium?

    e. What organism was seen in the water taken from the middle of the aquarium?

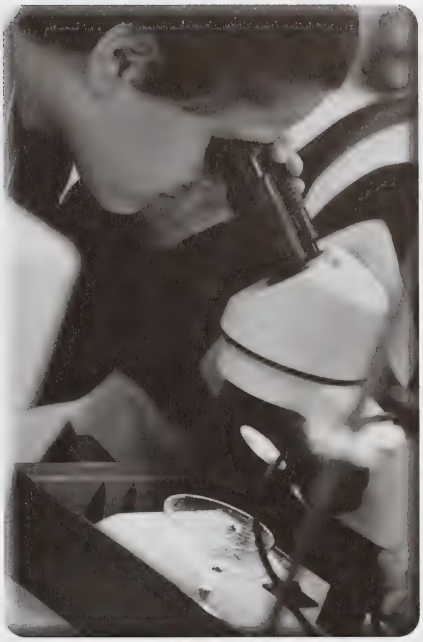
    f. What organism was seen in the water taken from the bottom of the aquarium?

13. Answer the following on page 250 of the textbook.

    a. questions 1 and 2 of "Analyzing and Interpreting"
    b. question 3 of "Forming Conclusions"


Check your answers with those on page 28.

When viewing cells through a microscope, you will see some of the structures of the cell. Developments and improvements in lens technology has led to the realization that the cell is an important part of living things. Recognizing that cells and cell functions are part of all living thing is known as cell theory.



Turn to pages 251 and 252 of the textbook and read "The Cell Theory."

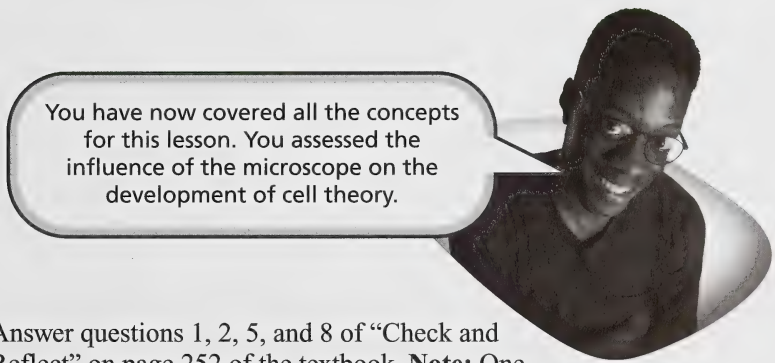
14. Who first proposed the cell theory and why?

15. State the three main ideas of the cell theory.

16. Which two types of organisms are not part of the cell theory?

Check Check your answers with those on page 28.

## Looking Back




17. Answer questions 1, 2, 5, and 8 of "Check and Reflect" on page 252 of the textbook. **Note:** One paragraph may be adequate to answer question 8.

Check Check your answers with those on pages 28 and 29.

Go to ... Go to pages 3 to 5 of Assignment Booklet 3A and answer questions 7 to 14.

## Glossary

**cell theory:** the theory stating that all living things are made up of cells, the smallest unit of life, and that all cells come from pre-existing cells

**controlled variable:** a condition that is held constant throughout an experiment

**spontaneous generation:** the theory that life could emerge spontaneously from non-living matter

## Suggested Answers

1. Aristotle first proposed the theory of spontaneous generation in about 350 BC.

2. Francesco Redi tried to disprove the theory of spontaneous generation by showing that maggots appeared when flies had access to meat and did not appear when flies could not access the meat.

3. The manipulated variable in Redi's experiment was the flies' access to the meat.

4. John Needham boiled chicken broth and put it in a flask and sealed it. Organisms still appeared after a while in the chicken broth in Needham's experiment. Since boiling was accepted as the method of killing living organisms, Needham suggested that there was a life force that produced spontaneous generation.

5. Lazzaro Spallanzani suggested that the organisms that grew in the flask came from the air that was in the flask before Needham sealed it.

6. Believers of spontaneous generation said that all Spallanzani did was show that air was required for spontaneous generation.

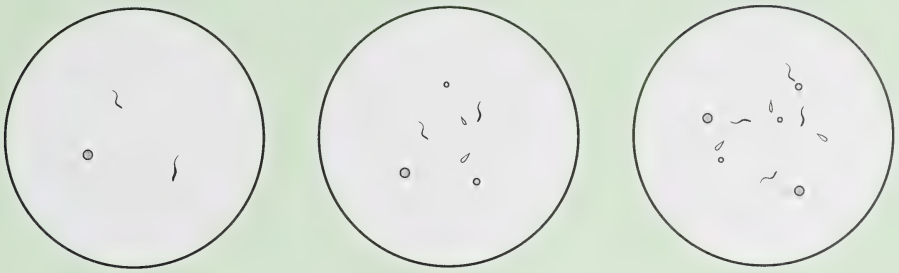
7. Louis Pasteur placed meat broth in a flask; then he heated and bent the neck of a flask into an "S" shape. He then boiled the broth in the flask and allowed it to cool. He found that no moulds grew in the broth, even after several years. Pasteur also showed that if the flask with the boiled broth is tipped so the broth reaches the "S" bend, moulds would later appear in the broth.

8. Pasteur's manipulated variable was the access of dust to the broth in the flask. His responding variable was the ability to grow mould in the broth.

9. Answers will vary. Some organisms that may be found in pond water are amoebas, anabaenas, nostoc, spirogyra, coleps, euglenas, parameciums, stentors, vorticellae, rotaria, and nematode worms.

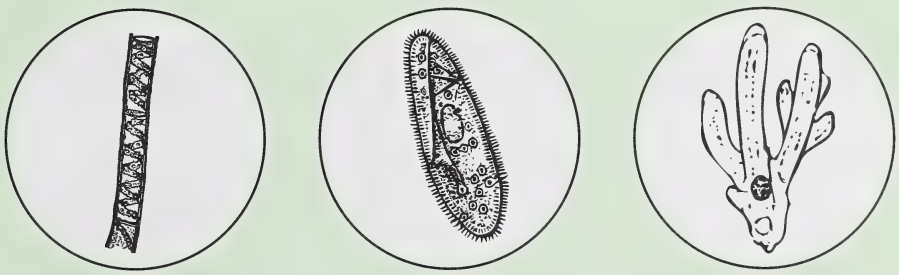
10. Diagrams will vary. Sample diagrams are given.

**Under a Low-Power Lens**



Water from Top | Water from Middle | Water from Bottom

**Under a High-Power Lens**



Water from Top | Water from Middle | Water from Bottom

11. a. **Textbook questions 1 and 2 of "Analyzing and Interpreting," p. 250**

    1. Yes, there were differences in the number and types of organisms at the different levels of water in the container. This indicates that organisms have different food, oxygen, and sunlight requirements.

    2. Answers will vary. You may have found many different kinds of organisms or only a few different types of organisms depending on your pond water. Pond water that has more organic material in it may have more organisms.

       Over time, the number of organisms in the container may increase and then decrease as food and oxygen supplies are depleted.

    b. **Textbook question 3 of "Forming Conclusions," p. 250**

    3. Pond water may have more diversity of organisms in it than aquarium water. Aquariums may have more chemicals added to the water, reducing the number and variety of organisms present.

12. a. Small organisms swimming around were seen.
    b. The organisms appear to be slightly larger under the medium-power lens.
    c. The organism stopped moving when Protoslo was used.
    d. A paramecium was seen.
    e. A paramecium was seen.
    f. An amoeba was seen.

13. Refer to the answer to question 11.

14. Matthias Schleiden and Theodor Schwann were the first scientists to propose the cell theory. They noticed that both plant and animal tissues have similar features that they proposed to call cells.

15. The three main ideas of the cell theory are as follows:

    - All living things are made up of one or more cells and the materials produced by these cells.
    - All life functions take place in cells, making cells the smallest unit of life.
    - All cells are produced from pre-existing cells through the process of cell division.

16. Two types of organisms not part of the cell theory are viruses and prions. These organisms are smaller than cells but still exhibit certain characteristics of living things. Prions are thought to be the cause of "Mad Cow Disease." You may wish to research prions on the Internet.

17. **Textbook questions 1, 2, 5 and 8 of "Check and Reflect," p. 252**

    1. Improvements in microscope lenses allowed scientists to make much more detailed observations of the structure of cells. This led to the observation of a nucleus in orchid cells by Robert Brown. Later, Matthias Schleiden observed that all plant cells have a nucleus. He concluded that the nucleus must be responsible for the development of the remainder of the cell. The advancements in microscopes also allowed Theodor Schwann to observe cells in animal tissue and to identify a nucleus in animal cells. This observation led to the theory that all plants and animals are made up of cells and that cells are the basic units of life.

    2. Spontaneous generation is the apparent appearance of living things out of non-living material. Examples include maggots appearing on rotting meat and mould growing on chicken broth in a sealed flask.

    5. Scientific inquiry is based on careful observation of a situation that then leads to a question or problem to be solved. The question or problem then leads to a hypothesis to be tested by an experiment. The scientific experiment performed must be controlled so that only one variable, the manipulated variable, changes. All other variables must be held constant. The scientific experiment must also include a control in which the manipulated variable is not changed from its normal state. The experiment should be repeatable so that the manipulated variable produces the same effect on the responding variable. The data collected should be published and be comparable to data obtained from other experiments investigating the same question.

8. The proponents of spontaneous generation would say the appearance of micro-organisms from the mixture of straw and water can be taken as life appearing from non-living material. The straw and water are non-living while the mass of growth that appears is living material. Those who oppose spontaneous generation would say that the living material must have been present in the mixture in a form that was not observable and that something then caused the living material to grow and form a visible mass of growth.

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# Lesson 3

## Developments in Imaging Technology and Staining Techniques

If you look at a drop of pond water through a microscope, you may notice that it is not always easy to see all the structures and detail. Using special staining techniques, scientists can highlight certain parts of organisms they are viewing so they are much more visible under a high-power microscope. A number of other techniques involving light correction, background enhancement, and variation in microscope types help scientists view images of organisms.

Technological advancements in enhancing images include adjusting contrast, increasing the resolution, using special contrast-enhancing techniques and fluorescence microscopy, using confocal technology, and using electron microscopy.

## Adjusting Contrast

**contrast:** the ability to see differences between structures in an image due to their ability to absorb light

Those who enjoy digital photography may have enhanced a digital photograph on their computer by simply changing the background colour or shading. This change would make the objects or people in the photograph more prominent. Similarly, you can change the **contrast** of a microscope image by adjusting the amount of light passing through the image being observed to make it more visible. Staining is also used to enhance the visibility of an image.

Turn to pages 253 and 254 of the textbook and read the introduction to "Developments in Imaging Technology and Staining Techniques" and the information in "Contrast."

1. How do stains enhance an image of a cell viewed under a microscope?

2. Describe a disadvantage of using staining techniques with slide images to be viewed under a microscope.

Check Check your answers with those on page 35.

## Quicklab

### Staining Cells

Read the entire activity on page 254 of the textbook.

3. What is the purpose of this activity?

Check Check your answer with the one on page 35.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Carefully follow the steps of the procedure on page 254 of the textbook. **Pay special attention to the safety precautions mentioned.**

4. Answer questions 1 to 4 of "Questions."

Check your answers with those on pages 35 and 36.

## Part B

Insert the Science 10 Multimedia CD into your computer, and view the segment "Staining Cells." Answer the following questions as you view the segment. You may have to stop the segment or go back as you answer the questions.

5. Describe how to stain onion skin cells.

6. How has the stain made the onion skin cells more visible?

7. Draw a diagram of an onion skin cell. Label the cell wall and the nucleus, and give the magnification of the cells under medium power.

8. How do the onion cells compare when stained with methylene blue and iodine?

9. Study Figure C1.14 on page 255 of the textbook closely.

   a. Describe the results for each of the staining techniques shown in Figure C1.14 on page 255.

   b. What is the effect of using different colours of stain?

Check your answers with those on page 36.

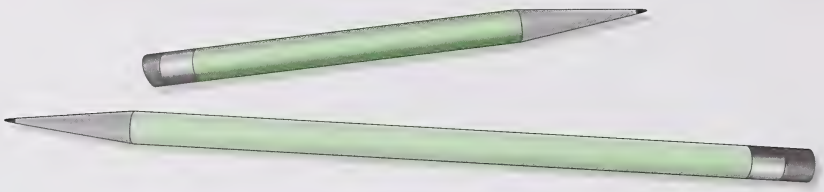
## Resolution

**resolution:** the ability to distinguish between two structures very close together

Magnification is how much you enlarge an image. You can magnify objects using high-power lenses. However, if the image becomes blurry then increasing the magnification is of no value. The ability of a light microscope to maintain a clear image with increasing magnification is the resolution of the microscope. With modern lens technology, the **resolution** of high-quality microscopes is limited by the wavelength of light.

Turn to pages 255 and 256 of the textbook and read "Resolution."

10. Try the activity described in the first paragraph of the reading involving the use of two pencils. What happens to the image of the two pencils as you move the pencils apart?



11. In Figure C1.15, the two images are taken with a digital camera. Digital cameras are rated according to the number of pixels (dots of colour) per unit area. Which picture of the flower has the higher resolution? Explain why.

12. What is the limit of resolution of the human eye?

13. What is the limit of resolution of the light microscope?

Check your answers with those on page 36.

## Enhancing Contrast

A number of techniques have been developed to improve images that can be seen under a light microscope. Read "Contrast Enhancing Techniques and Fluorescence Microscopy" on pages 256 and 257 of the textbook.

14. State four techniques that can be use to enhance images under a light microscope.

15. Describe fluorescence microscopy.

Check your answers with those on page 36.

For detailed information on various techniques used to enhance images under a light microscope, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Tech Ideas" or "Unit C: Hot Links" and scroll down to the corresponding text pages. You will be provided with a list of informative websites to choose from. Much of the information in these websites is fairly technical, so simply do a quick overview of the information.

**confocal technology:** a system that uses a light microscope, laser beams, and computers to produce a 3-D image from many images of thin slices of a specimen

## Confocal Technology

In addition to image-enhancement techniques for light microscopes, modern researchers use a special enhancing technique called **confocal technology**. In a regular light microscope, light that is out of focus comes through the specimen and forms part of the image. This causes a blurred image. With confocal technology, light that is out of focus is blocked, resulting in a sharper image.

For more information, read "Confocal Technology" on pages 257 and 258 of the textbook.

16. How is a 3-D image created with confocal technology?

17. How does the image of a nerve cell from a confocal microscope compare to the image of a nerve cell from a brightfield illumination image?

18. What is a benefit of fluorescence microscopy?

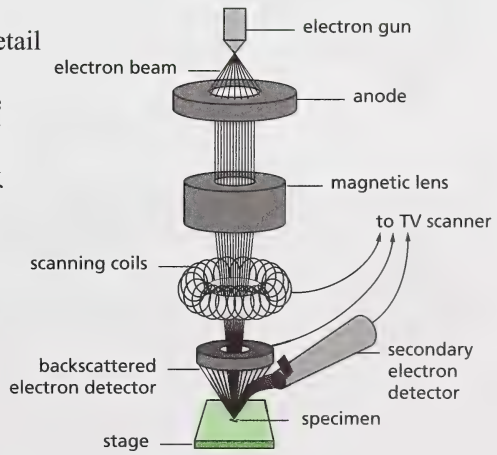
Check your answers with those on page 37.

## Electron Microscopes

**electron microscope:** an instrument that uses a beam of electrons to produce an image of a specimen

Special enhancement techniques have allowed light microscopes to reveal detail that would not even be considered possible when light microscopes were invented. However, the wavelength of light is a limiting factor on how much detail can be seen. In the latter half of the twentieth century, various types of **electron microscopes** have been developed. Because electrons are used to illuminate the specimens, the resolution of electron microscopes is about 2.5 nm (nanometres), which is over 100 times better than that of a light microscope.

**Parts of an SEM**



Turn to pages 258 to 260 of the textbook and read "Electron Microscopy." You will study various types of electron microscopes.

19. How is the image in an electron microscope produced?

20. Name two types of electron microscopes.

21. Describe the difference between the image produced by a TEM and by an SEM.

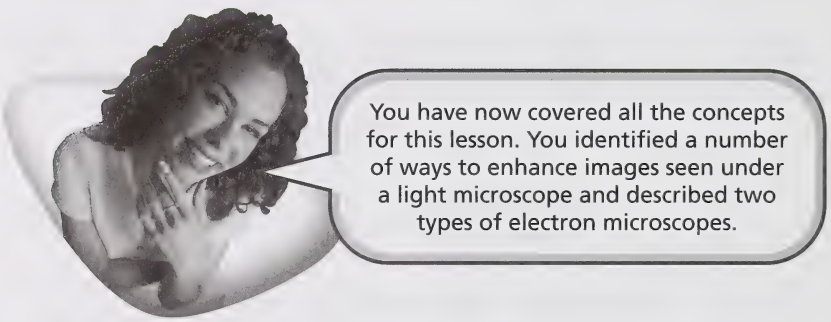
22. What are the photographs taken through an electron microscope called?

23. Describe four structures the electron microscope has allowed scientists to see.

24. Describe a drawback of the TEM.

Check Check your answers with those on page 37.

## Looking Back




25. Answer questions 1, 2, and 3 of "Check and Reflect" on page 260 of the textbook.

26. Explain how the development of the TEM led directly to a new understanding of cell structure and function.

Check Check your answers with those on page 37.

Go to ... Go to pages 5 to 7 of Assignment Booklet 3A and answer questions 15 to 21.

## Glossary

**confocal technology:** a system that uses a light microscope, laser beams, and computers to produce a 3-D image from many images of thin slices of a specimen

**contrast:** the ability to see differences between structures in an image due to their ability to absorb light

**electron microscope:** an instrument that uses a beam of electrons to produce an image of a specimen

**fluorescence microscopy:** a technique in which fluorescent substances are attached to desired molecules in a specimen that is then subjected to ultraviolet light

**light microscope:** an instrument that uses a system of lenses for magnification of a specimen illuminated by a beam of white light

**resolution:** the ability to distinguish between two structures very close together

**Scanning Electron Microscope (SEM):** an electron microscope that uses a beam of electrons to scan the surface of a specimen that has been fixed and covered with an electron-dense material, like gold

**Transmission Electron Microscope (TEM):** an electron microscope that passes an electron beam through a very thin section of a fixed and stained specimen

## Suggested Answers

1. Stains attach to particular parts of the cell, improving the contrast between various internal structures of the cell.

2. A disadvantage of using staining techniques is that the chemical preservatives used to "fix" the cell for staining and the stains themselves kill the cell. This prevents viewing live tissue.

3. The purpose of this activity is to use a staining technique to provide contrast in order to observe plant cells (onion cells).

4. **Textbook questions 1 to 4 of "Questions," p. 254**

    1. Onion cells are mostly narrow rectangular prisms, although some may appear to be cubes. The cell wall is clearly visible, particularly if the cells were stained with iodine. In cells stained with methylene blue, the nucleus is clearly visible.

    2. Parts in the pond-water organisms were not clearly distinguishable. The stained onion cells show more detail than the unstained cells.

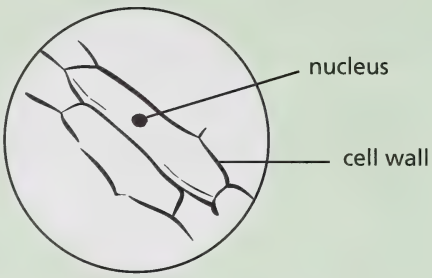
    3. Higher magnification results in greater detail. You may be able to observe the nucleus, grains of material distributed throughout the cell, and the cell wall.

4. Different colours of stain highlight different parts of the cell or different types of cells. Refer to Figure C1.14 on page 255 of the textbook.

5. To stain onion skin cells, you need to place a drop of stain at one side of the coverslip and use a paper towel to draw the stain under the coverslip into the onion skin cells.

6. The stain makes the cell wall, nuclei, and some of the contents of the onion skin cells more visible.

7. Diagrams should be similar to the one shown on the right. The magnification under medium power is $(10)(10)\times = 100\times$.




8. The cells stained with methylene blue shows the nuclei more clearly. The methylene blue does not, however, show the cell contents as darker areas within the cell wall like the iodine does.

9. a. (a) The staining of the epithelial cells shows the nuclei more prominently than the rest of the cell.

   (b) The nerve cell shows up as dark brown relative to the surrounding tissue. Also, the nucleus in the nerve cell shows up due to staining.

   (c) Staining shows the banding of the cytoplasm in muscle cells.

   (d) Staining and fixation shows the fat droplets as colourless areas within the tissue.

   b. The effect of using different colours of stain is that different parts of cells or different types of cells are highlighted.

10. The image of the two pencils becomes blurry as you move them further apart.

11. The picture of the flower on the right has the higher resolution because this image has more pixels (or dots of colour) per unit area.

12. The limit of resolution of the human eye is 0.1 mm, or $1\times10^{-4}$ m.

13. The limit of resolution of the light microscope is 0.2 μm, or $2\times10^{-7}$ m. This is half the wavelength of light.

14. Four techniques that can be used to enhance an image under a light microscope are brightfield illumination, darkfield illumination, phase contrast illumination, and differential interference contrast illumination.

15. Fluorescence microscopy uses fluorescent substances that attach to certain molecules in the tissue. When the specimen is subjected to ultraviolet light, the molecules with the fluorescent substances glow.

16. An image of a very thin section through the specimen is produced and stored on a computer. Images of many of these sections are then combined to produce a 3-D image.

17. The image of a nerve cell from a confocal microscope allows scientists to see the finely branched structure of the dendrites.

18. The benefit of fluorescence microscopy is that fine detail of living cells can be studied.

19. The image in an electron microscope is produced by the absorption or scattering of an electron beam by electron-dense materials in the specimen.

20. Two types of electron microscopes are the Transmission Electron Microscope (TEM) and the Scanning Electron Microscope (SEM).

21. The TEM produces images of the interior of a specimen; the SEM produces images of the surface of a specimen.

22. Photographs taken through an electron microscope are called electron micrographs.

23. Four structures the electron microscope has allowed scientists to see are

    - details of the nucleus and the nuclear envelope
    - nuclear pores in the nuclear envelope
    - two layers in the cell membrane
    - cilia on cells

24. A drawback of the TEM is that the area covered by each image is very small so it is difficult to build up a three-dimensional image. Also, the specimen is fixed and non-living.

25. **Textbook questions 1, 2, and 3 of "Check and Reflect," p. 260**

    1. The advantage of using a light microscope is that live organisms can be observed. Other advantages might include ease of setup and use and low cost. A disadvantage is that the resolving power of a light microscope is limited by the wavelength of light.

    2. Investigators (scientists) need to stain cells in order to increase the contrast between various internal structures. This produces better images.

    3. Electron microscopy is needed when the objects to be viewed are too small or too close together to be viewed with a light microscope.

26. The development of the TEM led directly to a new understanding of cell structure and function because it provided detail of the structure of parts of the cell, such as the nucleus, mitochondria, Golgi apparatus, ribosomes, and the two-layer structure of the cell membrane. A detailed view of these parts led to an understanding that all cells have common parts that work together to provide life functions for the cell and the organism.

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# Lesson 4

## Cell Research at the Molecular Level

New developments in electron microscope technology is leading to cell research at the molecular level. The Scanning Tunnelling Microscope (STM) and the Atomic Force Microscope (AFM) are two new electron microscopes that allow researchers to "see" individual atoms and molecules. Actually, the microscope "feels" the individual atoms or molecules by scanning the surface of an object with an ultra-fine tip. A computer program is then used to produce an image of the scanned surface.

**gene mapping:** a technique used to locate the position of specific genes within the genetic make-up of an organism

**Figure 1.2:** An STM image of individual iron atoms on a copper surface [1]

You can learn more about these electron microscopes by entering the words *Scanning Tunnelling Microscope* or *Atomic Force Microscope* in any of the Internet's search engines.

With the help of new microscope technology, scientists have been able to go within the cellular level and study the genetic material on a molecular level. This has led to **gene mapping** many plant and animal species.

Turn to page 261 of the textbook and read "Gene Mapping." Examine the two images in Figure C1.24 closely. Both images are of DNA molecules. The bumps in the image in (b) would be the same as the dots in the computer artwork in (a). The image in (b) is showing only part of one twist in the helix formation of DNA.

[1] Image reproduced by permission of IBM Research, Almaden Research Center. Unauthorized use not permitted.

For a similar comparison of the helical twists of DNA as "seen" by a Scanning Tunnelling Microscope (STM), visit

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Pages 261–263. In the list of links given, click on *Future of Genetic Research*.

1. What is the Human Genome Project?

2. What benefits might result from DNA analysis and gene mapping research?

3. What problems might result from DNA analysis and gene mapping research?

Check your answers with those on page 42.


**Figure 1.3:** Genetic research has led to genically modified varieties of corn that are disease resistant.

The results of changes in human DNA are largely unknown at this time. How new crop varieties may affect the ecosystem is also an unknown. Who controls the costs and profits of such research?

For more information on the ethics of DNA analysis and gene mapping research, go to the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and research some of the links regarding the Human Genome Project and ethics as well as bioethics.

In the next activity you will look at the risks and benefits of modifying rice genes. A risk-benefit analysis separates what you think are the positive aspects of an issue from what you think are the negative aspects of the issue. You need to be able to support what you put in each list with reasoning.

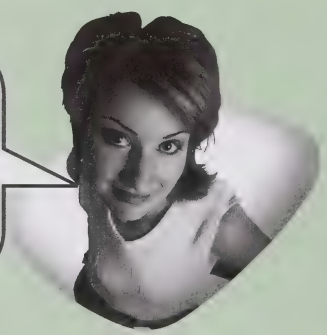
## Decision-Making Investigation

### Gene Mapping: Opportunity or Risk?

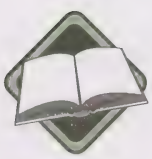
Turn to page 263 and read "The Issue" and "Background Information."

4. Answer questions 1 to 4 of "Analyze and Evaluate."

For question 3, due to the extensive amount of information, limit your discussion to a brief description of the research being done. For question 4, enter *risks and benefits of biotechnology* in any of the Internet's search engines.



Check your answers with those on pages 42 and 43.

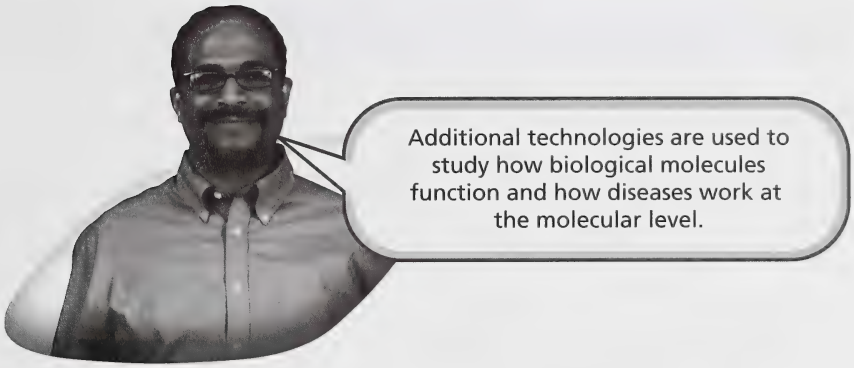


Did you know that cells can "talk" to one another? In order for cells to function efficiently, they must be able to communicate with each other. Cells communicate through messenger molecules that travel through the bloodstream.

Turn to page 262 of the textbook and read the information in "Cell Communication."

5. Explain how cells communicate.

Check your answer with the one on page 44.




Read the information on page 264 of the textbook to study X-ray crystallography and Green Fluorescent Protein (GFP) technology.

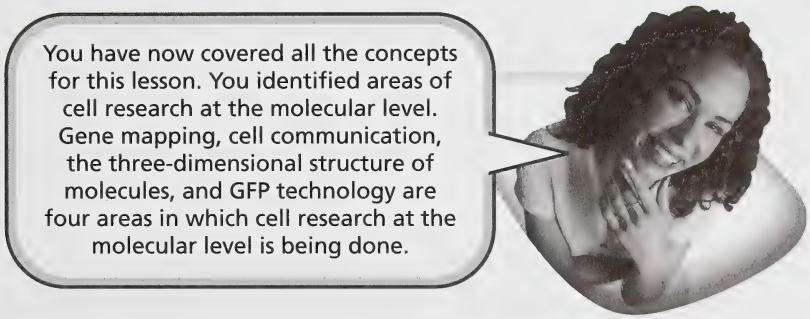
6. How is X-ray crystallography used to determine how molecules work?

7. What is Green Fluorescent Protein (GFP) technology?

8. How is GFP technology used to study degenerative diseases of the nervous system?

Check Check your answers with those on page 44.

## Looking Back




9. Answer questions 2, 3, 6, and 8 of "Check and Reflect" on page 264 of the textbook.

Check Check your answers with those on page 44.

Go to ... Go to pages 7 and 8 of Assignment Booklet 3A and answer questions 22 to 25.

## Glossary

**cell communication:** the ability of cells in an organism to interact with each other and to influence each other's activity

**gene mapping:** a technique used to locate the position of specific genes within the genetic make-up of an organism

**Green Fluorescent Protein (GFP) technology:** a process that allows cell activities to be studied by attaching green fluorescent protein to particular parts of the cell

**X-ray crystallography:** the study of the structure of molecules using X rays, sensors to analyze the scattering of the X rays, and computer technology to analyze the data

## Suggested Answers

1. The Human Genome Project is the complete genetic map of the positions of all the genes in human genetic material.

2. DNA analysis and gene mapping research may one day allow scientists to manage or cure disease-causing abnormalities, such as cancer, or to develop new varieties of crops that are pest and/or drought resistant.

3. Ethical issues about ways in which research is applied might result from DNA analysis and gene mapping research. Society must provide guidelines for how science is to be conducted with respect to DNA research.

4. **Textbook questions 1 to 4 of "Analyze and Evaluate," p. 263**

    1. A risk is a negative effect of modifying cells at the molecular level. A benefit is a positive effect of modifying cells at the molecular level.

    2.

| Risks | Benefits |
|---|---|
| • Concentrating on a few varieties will reduce diversity.<br>• New diseases could wipe out an entire monoculture crop. For example, much of the corn crop was wiped out in the 1970s by blight because only one variety was planted. | • Plants that are disease- or drought-resistant can be produced.<br>• Strains of rice that have higher yields and nutritional value will be developed. |

| | |
|---|---|
| • Farmers may have to pay higher prices for new seed to remain competitive. This has happened with varieties of canola.<br>• Health concerns of genetically modified crops are unknown.<br>• The qualities of disease resistance or drought tolerance could be transferred to weed species. | • Benefits of modifying rice varieties can be applied to other cereal grains. |

3. Answers will vary. The following is a brief description of some of the research that is being conducted in biotechnology in Canada and worldwide.

   There is extensive research for gene mapping various types of plants. Research on how specific genes for higher yield, drought tolerance, or disease resistance can be taken from one variety and transferred into another is being conducted worldwide.

   In Canada, research on genetic modification in cereal crops is mainly concentrated on wheat and canola. The Canadian government, as well as many companies, are involved in this research. Canadian agricultural biotechnology regulations are respected worldwide.

   Extensive research involving hard red spring wheat and durum wheat is being done in North Dakota, U.S. The purpose of the research is to develop varieties that are resistant to various fungal and viral diseases. Research on disease-resistant varieties is also being done on barley and oat crops.

   Worldwide, research on gene modification in rice, sorghum, and maize (corn) is being conducted largely through the Cuulong Delta Institute. This is an organization of various Asian countries and Australia that are involved in biotechnology research. Much of the research is centred around modifying rice varieties.

4. Answers will vary. The following is a sample answer for the president of an agrochemical company.

| Risks | Benefits |
|---|---|
| • expensive research required<br>• potential for law suits if problems from biotechnology arise<br>• value of genetically modified foods (GMOs) may be hard to sell to public | • high marketability of products<br>• improved food quality and shelf life<br>• high economic value in research |

5. Cells communicate through molecules that travel through the bloodstream and attach to specialized molecules on the surface of a target cell. These specialized molecules are called receptors and may trigger a chain reaction to send the message to the proper location within the target cell.

6. X-ray crystallography is used in combination with computer technology to determine whether molecules are coiled or straight and whether the molecule is made of repeated units. Analyzing the shape of normally functioning protein molecules and defective proteins may enable scientists to find the parts of the molecule that control activity of the proteins.

7. In GFP technology, special fluorescent proteins from luminescent jellyfish are attached to particular parts of a cell to indicate what is happening with that part of the cell.

8. Fluorescent proteins are attached to both normally functioning and abnormally functioning proteins. A comparison can be made of changes to both proteins over time.

9. **Textbook questions 2, 3, 6, and 8 of "Check and Reflect," p. 264**

    2. The three technologies used in X-ray crystallography are X rays, special sensors that analyze patterns of the scattering X rays, and computer technology to allow scientists to learn the details of molecular structure and how molecules work.

    3. One advantage of using GFP technology in cell studies is that it can be used with live specimens. This allows a comparison between diseased and healthy living cells.

    6. Additional information you might want on the issue of gene mapping include the following:

        - ownership of patents on genetically modified organisms
        - access to the technology
        - sources of funding for research on genetically modified organisms

    8. Job opportunities in the area of molecular research in biochemistry include the following:

        - senior research scientist to head a team of research scientists
        - cell biologist
        - research scientist to synthesize various compounds for prescription drugs
        - assistant editor for publishing journal
        - laboratory assistant to maintain the cleanliness of the work areas and glassware and to maintain inventories of required supplies

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# Conclusion

In this section you learned about microscopy and the emergence of cell theory. You traced the development of cell theory and described how advancements in cell structure and function are a direct result of developments in microscope technology.

The technological advancements in electron microscopy have opened up a huge area for research in areas of molecular biology, molecular chemistry, biophysics, and micro-robotics. Nanotechnology is a new area of research involving characteristic dimensions of less than 1000 nanometres ($1 \text{ nm} = 10^{-9} \text{ m}$). Nanotechnology will allow the building of devices on a molecular scale.

The new developments have opened many careers in scientific research. A National Institute of Nanotechnology has been established at the University of Alberta. Can you see yourself in a career in the field of scientific research?

# Functions of Cell Structures and Organelles

You are an active person. Cells are multiplying; your body is growing; and its systems are interacting. Food is digested, absorbed, and transported to various parts of your body as needed. Wastes are removed and transported to the proper organs and excreted. Did you know that each of the millions of cells in your body carry on all of the life processes?

How are cells capable of carrying on processes like the intake of nutrients, exchange of gases, waste removal, and reproduction?

In this section you will identify the various organelles of plant and animal cells and describe how these organelles carry out the functions necessary for the cell to survive.

Turn to page 266 of the textbook and read the introduction to Unit C 2.0. Pay particular attention to the key concepts and learning outcomes listed. They provide you with a quick overview of the material you will be studying in this section.

# Lesson 1

## The Cell as an Efficient, Open System

**photo-micrograph:** a photograph taken through a microscope

Each dark spot in the cells in the **photomicrograph** is the nucleus of the individual cells. The nucleus is just one of the organelles of a cell that work to carry out the life processes of the cell. As you discovered earlier regarding the magnification of a simple light microscope, only the nucleus, cytoplasm, and cell wall are visible.

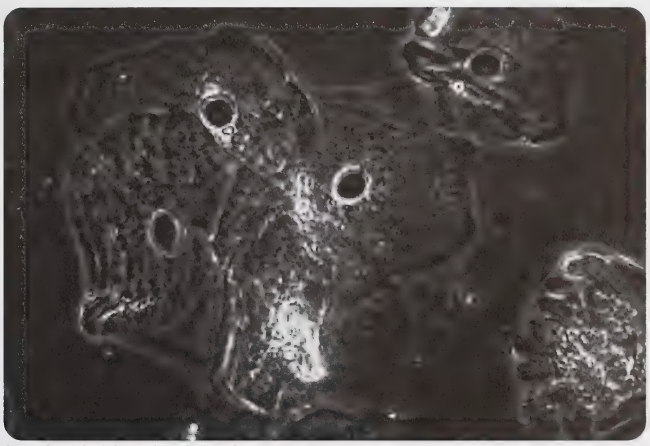

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**Figure 2.1:** Photomicrograph of cheek epithelial cells in phase contrast

Turn to page 267 of the textbook and read the introductory paragraphs of "The Cell as an Efficient, Open System" and the information in Table C2.1.

**open system:** any system that exchanges both matter and energy with its surroundings

1. Why is a cell considered an **open system**?

2. List the life processes carried on by cells.

3. Name and describe the three organelles visible in the photomicrograph in Figure C2.2. Copy and complete a chart like the following.

| Cell Structure | Function |
|---|---|
| | |

4. What is the magnification of the photomicrograph in Figure C2.2?


Check your answers with those on page 52.

Using the technology described Section 1, scientists have been able to see all of the organelles present in a cell.

Turn to pages 268 and 269 of the textbook to see photomicrographs of more organelles present in plant and animal cells.

5. Extend the chart you completed in question 3 to include the organelles mentioned on pages 268 and 269 of the textbook.

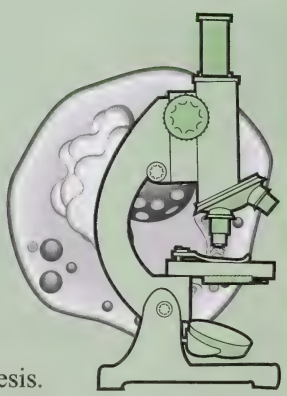
6. How do the magnification of the organelles on pages 268 and 269 compare with the magnification of the organelles on page 267 of the textbook?

Check Check your answers with those on pages 53 and 54.

## Inquiry Lab

### Comparing Structures in Plant and Animal Cells

Read the entire activity on page 271 of the textbook. In this activity you will compare structures found in plant cells with those found in animal cells.



If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

#### Part A

7. Re-read "The Hypothesis"; then state your hypothesis.

Check Check your answer with the one on page 54.

Complete the activity as described in steps 1 to 3 of the procedure. **Pay special attention to the safety precautions mentioned—broken glass has sharp edges.**

8. Answer the following on page 271 of the textbook.

    a. questions 1, 2, and 3 of "Analyzing and Interpreting"
    b. question 4 of "Forming Conclusions"
    c. question 5 of "Applying and Connecting"


Check your answers with those on page 54.

## Part B

9. Compare the plant cell and animal cell in Figure C2.10 on page 270 of the textbook.

    a. Which structures are similar in the two cells?
    b. Which structures are different?

10. Why might some organelles not be visible under a light microscope?


Check your answers with those on page 55.

In the preceding activity you observed that only some cell organelles are visible under a light microscope. Images of the organelles that are not visible under a light microscope can be produced by various types of electron microscopes. These images are then used to make inferences about the function of these organelles.

The study of the various cell organelles provide scientists with information on the chemical composition of cell structures and help them create models of the structures.

Read "The Chemical Composition of Cell Structures" and "A Model of the Cell Membrane" on pages 271 to 273 of the textbook. You will cover some of the compounds present in plant and animal cells, and you will examine a model of a cell membrane.

11. List the four organic compound types present in plant and animal cells.

12. What major elements make up the organic compounds present in cells?

13. What substance provides the environment for all biological reactions inside and outside the cell?

14. Name four trace elements essential for the health of the cell.

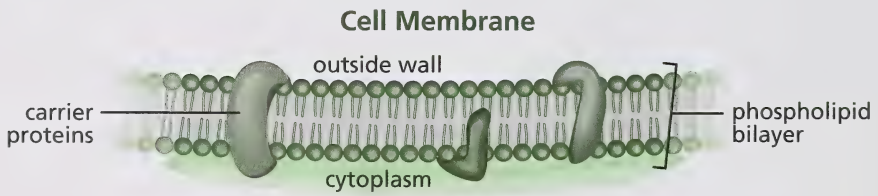
15. Copy and complete the following table describing the similarities and differences between plant and animal cells. One similarity and one difference have been done for you.

| Similarities | Differences |
|---|---|
| • Both cells have a cell membrane. | • Animal cells have centrioles, which are involved in cell division. |

16. Describe the role of the cell membrane.

17. Describe what makes up the cell membrane.


Check your answers with those on pages 55 and 56.




By allowing only certain substances in and others out, the cell membrane protects the cell's fragile contents.

For more information on the cell membrane, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Pages 271–272. You will find a list of sites about the cell membrane, including a 3-D model of the cell membrane and information on how water and other substances go in and out of the cell.

## Looking Back

You have now covered all the concepts for this lesson. You identified the various parts of plant and animal cells and described the function of each. You listed some of the chemical compounds that make up cells and described the differences between plant and animal cells in terms of their chemical composition. You described a model of the cell membrane and described its function.

18. Answer questions 1, 2, 4, and 10 of "Check and Reflect" on page 273 of the textbook.


Check your answers with those on page 56.


Go to pages 1 to 3 of Assignment Booklet 3B and answer questions 1 to 9.

## Glossary

**cell membrane:** a protective barrier that surrounds the cell and allows the transport of nutrients into the cell and wastes out of the cell

**cell wall:** a rigid, protective layer around the cell in plants, bacteria, and some protists

**chlorophyll:** a green pigment that makes photosynthesis possible

**chloroplast:** an organelle found in plants and some protists that contains chlorophyll and is the site of photosynthesis

**cytoplasm:** a gel-like substance inside the cell membrane in which the organelles are suspended

**cytoplasmic streaming:** the distribution of material within a cell through the circular flow of cytoplasm

**endoplasmic reticulum:** a network of membrane tubes that branch out from the nuclear envelope and circulate materials throughout the cell

**Golgi apparatus:** a flat stack of membranes that receive, modify, and transport products of the endoplasmic reticulum throughout the cell

**lysosome:** an organelle containing enzymes that digest food, destroy bacteria, and break down damaged organelles in cells

**nuclear envelope:** a double-layered membrane that separates the nuclear contents from the cytoplasm

**nucleus:** the organelle that contains the genetic material of the cell and directs all cell activities

**open system:** any system that exchanges both matter and energy with its surroundings

**phospholipid bilayer:** the double layer of outward-facing phosphates and inward-facing lipids that form a cell membrane

**photomicrograph:** a photograph taken through a microscope

**ribosome:** an organelle in the cell that is the site of protein synthesis

**vacuole:** a membrane-enclosed sac in a cell that serves to store nutrients, products of secretion, or fats

**vesicle:** a membrane-enclosed sac that transports materials in a cell; similar to a vacuole

## Suggested Answers

1. A cell is considered an open system because it is able to exchange matter and energy with its surroundings.

2. The life processes carried on by cells are as follows:

   - intake of nutrients
   - movement
   - growth
   - waste removal
   - response to stimuli
   - exchange of gases
   - reproduction

3. Your completed chart should be similar to the following.

| Cell Structure | Function |
|---|---|
| cell membrane | The cell membrane is a protective barrier that surrounds the cell and allows the transport of nutrients into the cell and wastes out of the cell. It is also important for cell interaction and communication. |
| cytoplasm | The cytoplasm is a gel-like substance inside the cell membrane in which the organelles are suspended and that contains the nutrients required by the cell. The nature of the cytoplasm allows for movement of organelles and molecules within the cell. |
| nucleus | The nucleus is the organelle that contains the genetic material of the cell and directs all cell activities. The nucleus is surrounded by a nuclear envelope that allows the transport of molecules in and out. |

4. The magnification in the photomicrograph is approximately 300×.

5. Your completed chart should be similar to the following.

| Cell Structure | Function |
|---|---|
| cell membrane | The cell membrane is a protective barrier that surrounds the cell and allows the transport of nutrients into the cell and wastes out of the cell. It is also important for cell interaction and communication. |
| cytoplasm | The cytoplasm is a gel-like substance inside the cell membrane in which the organelles are suspended and that contains the nutrients required by the cell. The nature of the cytoplasm allows for movement of organelles and molecules within the cell. |
| nucleus | The nucleus is the organelle that contains the genetic material of the cell and directs all cell activities. The nucleus is surrounded by a nuclear envelope that allows the transport of molecules in and out. |
| cell wall | A rigid frame around the cell that provides strength and support. The cell wall is found in plant cells, bacteria, some protists, and fungi. |
| chloroplasts | Green organelles that contain chlorophyll and are found only in plants. Chloroplasts are the sites of photosynthesis. |
| vacuoles and vesicles | Vacuoles and vesicles are membrane-bound organelles that serve to store nutrients, products of secretion, and fats. In plants, the central vacuole swells and increases turgor pressure. The vacuole in Figure C2.4 is almost all of the interior of the cell. |
| endoplasmic reticulum | The endoplasmic reticulum is a series of interconnected small tubes that branch out from the nuclear envelope and transport materials. There are two types: rough endoplasmic reticulum (associated with protein synthesis) and smooth endoplasmic reticulum (associated with fat and oil production). |
| ribosomes | Ribosomes are dense-looking granules formed of two parts that may be attached to the rough endoplasmic reticulum or may be free in the cytoplasm. Ribosomes are the sites of protein synthesis. |
| lysosomes | Lysosomes are membrane-bound sacs in which digestion can occur. Other roles of lysosomes include defense against invading bacteria, destruction of damaged cell organelles, and controlled digestion of certain tissues during development. |
| Golgi apparatus | The Golgi apparatus is composed of flat, disc-shaped sacs that receive substances from the endoplasmic reticulum and packages them for transport out of the cell. |
| mitochondria | Mitochondria are rod-like structures where cellular respiration occurs. |

6. The magnification of the organelles on pages 268 and 269 is much greater than the magnification of the organelles on page 267 (from 2000× to 340 000× compared to 300×).

7. There are differences between a plant and animal cell that can be observed using a light microscope.

8. a. **Textbook questions 1, 2, and 3 of "Analyzing and Interpreting," p. 271**

   1. The following are cell structures that are generally visible under a light microscope in animal and plant cells.

| Plant Cell | Animal Cell |
|---|---|
| • cell membrane (may be difficult to see next to the cell wall)<br>• cytoplasm<br>• nucleus<br>• cell wall<br>• chloroplasts<br>• central vacuole (may not be visible in the prepared slides) | • cell membrane<br>• cytoplasm<br>• nucleus |

   2. The cell membrane should be similar in both plant and animal cells; it may, however, be difficult to see in the plant cell because it is next to the cell wall. The nucleus appears to be similar in both plant and animal cells. The cytoplasm is similar in both plant and animal cells, but the cytoplasm in the plant cell may contain chloroplasts if the cell is one where photosynthesis is carried out.

   3. The high-power lens reduces the area viewed but increases the detail seen.

   b. **Textbook question 4 of "Forming Conclusions," p. 271**

   4. Plant and animal cells have similar cell membranes, nuclei, and cytoplasms. The plant cell has a cell wall, chloroplasts, and a large central vacuole. The animal cell does not have these structures.

   c. **Textbook question 5 of "Applying and Connecting," p. 271**

   5. Not all the organelles shown in Figures C2.10 are visible under the light microscope because they are too small. Notice that the organelles that do not show up are the ones shown on pages 268 and 269 of the textbook. These are only visible under high magnification.

9. a. The structures that are similar are the nucleus, nuclear envelope, rough endoplasmic reticulum, smooth endoplasmic reticulum, ribosomes, Golgi apparatus, mitochondrion, lysosomes, and cytoplasm. **Note:** Lysosomes are labelled in the animal cell. In the plant cell there is a lysosome shown that is not labelled.

   b. The cell wall, chloroplasts, and central vacuole are only present in the plant cell.

10. Some organelles may not be visible under a light microscope because they are too small. Those that are not visible under a light microscrope are the ones listed on pages 268 and 269 of the textbook.

11. The four organic compound types present in plant and animal cells are lipids, carbohydrates, proteins, and nucleic acids.

12. The major elements are carbon, hydrogen, oxygen, and nitrogen.

13. Water provides the environment for all biological reactions inside and outside the cell.

14. Four trace elements essential for the health of the cell are magnesium (Mg), zinc (Zn), manganese (Mn), and iron (Fe).

15. Your completed table should be similar to the following.

| Similarities | Differences |
|---|---|
| • Both cells have a cell membrane.<br>• Both cells have a cytoskeleton made up of proteins and lipids.<br>• Both cells have genetic material (DNA) made up of sugars, nitrogen bases, and phosphate. | • Animal cells have centrioles, which are involved in cell division.<br>• Plant cells have a rigid cell wall made of cellulose.<br>• Plant cells have a specialized chemical, called chlorophyll, that makes photosynthesis possible. **Note:** There are plant cells, such as the cells in underground roots, that do not contain chlorophyll. In these cells, chlorophyll would not be advantageous due to the absence of light.<br>• Some animal cells have specialized compounds, like hemoglobin in red blood cells and cholesterol in other cells.<br>• Some plant cells store energy in the form of starch or oils, whereas animal cells may contain glycogen or lipids.<br>• Plant cells have a large central vacuole, whereas vacuoles and vesicles in animal cells are small. |

16. The role of the cell membrane is to maintain equilibrium inside the cell. This is accomplished by keeping some substances in and other substances out.

17. The cell membrane is made up of a double layer of lipids with a phosphate group attached to each lipid. In Figure C2.12 (b), the light-coloured, inner region is the double layer of lipids and the blue layers on each side are the phosphate groups.

18. **Textbook questions 1, 2, 4, and 10 of "Check and Reflect," p. 273**

    1. A system is any unit, structure, or process that has many parts that work together for a particular goal.

    2. The cell is an open system because it exchanges energy and matter with its surroundings.

    4. a. The cell membrane consists of a double layer of lipids with a phosphate group attached to each. The cell membrane functions as a protective barrier around a cell, allowing substances to enter and leave the interior of the cell.

       b. Vacuoles are storage sites for nutrients, secretions, fats, and water. In plant cells, the central vacuole is a large storage area for water that swells to create turgor pressure.

       c. Mitochondria are rod-like structures where cellular respiration takes place.

       d. Chloroplasts contain chlorophyll and are the site of photosynthesis in plant cells.

    10. Both plant and animal cells have a cell membrane, nucleus, cytoplasm, mitochondria, ribosomes, endoplasmic reticulum, vacuoles, and vesicles. The plant cell has a rigid cell wall that encloses the cell and gives support. Plant cells (in green tissue) have chloroplasts and can produce their own food. Animal cells need support from other structures, such as skin cells and bone cells, and cannot produce their own food. Plant cells have a large central vacuole, whereas animal cells have small vacuoles.

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# Lesson 2

## The Role of the Cell Membrane in Transport

Many people, young and old, enjoy a nice cup of tea now and then; but how many view making a cup of tea from a scientific point of view? Have you ever watched what happens when you place a tea bag into a cup of hot water? Even without stirring, colour immediately begins to seep from the tea bag to the water and spread throughout the cup. This movement of colour is evidence of **diffusion**—particles of tea moving from an area of higher tea concentration to an area of lower tea concentration.

**diffusion:** the spontaneous movement of particles from an area of higher concentration to an area of lower concentration

Diffusion also plays an important role in the movement of various substances into and out of the cell through the cell membrane. You can better understand diffusion and other methods of transport through the cell membrane if you relate them to the particle model of matter.

Turn to page 274 of the textbook and read the introduction to "The Role of the Cell Membrane in Transport" and "The Particle Model of Matter."

1. What are all the substances that enter and leave the cell regarded as?

2. Hypothesize how the four main points in the particle model of matter relate to how substances can move through a cell membrane.

Check your answers with those on page 66.

Have you been in a room when someone has opened a new package or container of coffee? How long did it take for the smell of fresh coffee to waft over to you? How did the smell of the coffee get from the package to you if you're across the room?

Particles move from an area of higher concentration to an area of lower concentration through a process called diffusion. Since particles of air are in constant motion, the aroma molecules released by the coffee travel through the air in all directions. Diffusion of substances also occurs through the cell membrane when there is a difference in concentration inside and outside the cell membrane.

Turn to page 275 of the textbook and read "Diffusion." You will study more about diffusion and how it occurs through the cell membrane.

3. What happens to the coffee aroma molecules released into a room after a period of time?

4. a. What is rate of diffusion?
   b. How can rate of diffusion be changed?

5. Define *concentration gradient*.

6. Why is the movement of a substance through diffusion called passive transport?

7. Why is the cell membrane considered to be a selectively permeable membrane?

8. State three conditions that determine whether materials will pass through a cell membrane.

9. Why does carbon dioxide leave a cell and oxygen enter a cell?

Check Check your answers with those on page 66.

# Inquiry Lab

## Movement Across a Semi-Permeable Membrane

Turn to page 276 of the textbook and read the entire activity.

10. Write a hypothesis for this activity.


Check your answer with the one on page 66.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

### Part A

Carefully follow the steps of the procedure outlined on page 276 of the textbook. In this activity you will test the movement of iodine through a semi-permeable membrane. **Pay close attention to the safety precautions mentioned**.

11. Copy and complete the following table to record your observations in steps 5, 6, and 7 of the procedure.

| Container | Observations |
|---|---|
| Test Tube 1 | |
| Test Tube 2 | |
| Test Tube 3 | |
| Test Tube 4 | |
| starch solution in bag | |
| beaker with water and iodine | |

12. Answer the following on page 276 of the textbook.

    a. questions 1 to 4 of "Analyzing and Interpreting"
    b. question 5 of "Forming Conclusions"


Check your answers with those on page 67.

## Part B

Insert the Science 10 Multimedia CD into your computer, and view the segment "Movement Across a Semi-Permeable Membrane." Answer the following questions as you view the segment. You may have to stop or go back as you answer the questions.

13. Copy and complete the following table.

| Container | Observations |
|---|---|
| Test Tube 1 | |
| Test Tube 2 | |
| Test Tube 3 | |
| Test Tube 4 | |
| Test Tube 5 | |
| Test Tube 6 | |
| beaker with water and iodine | |
| starch solution in bag | |

14. What colour did the solution in the beaker and the solution in the plastic bag change to?

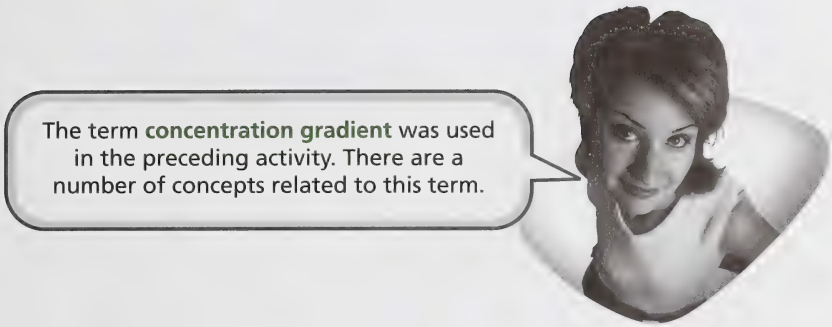
15. What does the change in colour indicate about what exchange took place between the solution in the beaker and the solution in the plastic bag?

16. Do the results of the experiment support the hypothesis made by the student in the video?

17. What is the purpose of Test Tubes 1 and 3?


Check your answers with those on page 68.

**concentration gradient:** the difference within a given area or region of the highest and lowest concentrations of a substance




Read "Concentration Gradients" on page 277 of the textbook. Study Figure C2.15 closely.

18. State the five points related to concentration gradients.

19. How did the plastic bag in the preceding Inquiry Lab behave like a semi-permeable membrane?

Check Check your answers with those on page 68.

**osmosis:** the diffusion of water across a selectively permeable membrane

The process by which water enters a cell through the membrane is given a special name. You may have heard this term used with water filters. The diffusion of water from an area of lower solute (higher water) concentration to an area of higher solute (lower water) concentration across a cell membrane is called **osmosis**.

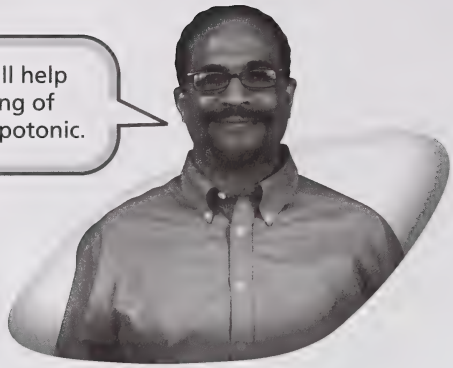
Read the information in "Osmosis" on pages 277 and 278 of the textbook. Carefully examine Figure C2.16.

20. Explain, in terms of water concentrations, why water flows from left to right in Figure C2.16.

21. Define the following terms with reference to concentration of solutions outside and inside a cell.

    - *hypertonic*
    - *isotonic*
    - *hypotonic*

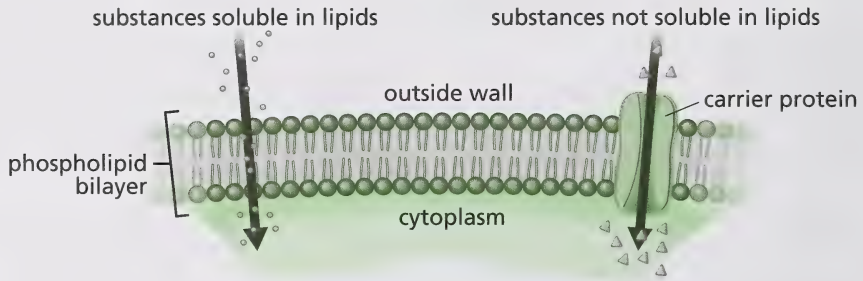
Check Check your answers with those on pages 68 and 69.




22. Answer questions 1 to 4 of "Skill Practice: Linking Conclusions to Hypotheses" on page 279 of the textbook.

Check Check your answers with those on page 69.

The lipid bilayer in the cell membrane allows only molecules of substances that are soluble in lipids to pass through. Substances that are not soluble in lipids need some other mechanism to pass through the membrane.




Turn to pages 278 and 279 of the textbook and read the information in "Facilitated Diffusion" and "Active Transport." You will study different ways substances can pass through the cell membrane.

23. Define the terms *channel proteins*, *carrier proteins*, and *facilitate diffusion*.

24. a. What is active transport?
    b. Where does the energy for active transport come from?
    c. How is active transport different from diffusion and facilitated diffusion?

Check Check your answers with those on page 69.

In the next activity you use a hen's egg to demonstrate osmosis. You will either measure the change in mass of the egg due to osmosis or you will observe the effect of osmosis on the size and shape of the egg.

Quicklab

## The Incredible Egg

Turn to page 280 of the textbook and read the entire activity.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

### Part A

Obtain all the required materials and equipment, and carefully follow the steps outlined in the procedure. **Pay special attention to the safety precautions mentioned.**

25. Copy and complete the table given at the bottom of page 280.

26. Answer questions 1 to 5 of "Questions."


Check your answers with those on page 70.

### Part B

Complete the activity as described in the procedure on page 280 of the textbook; but do not measure the mass of the egg. Observe the changes in appearance and size as the egg is placed in the salt solution and, then, in the distilled water. Use vinegar to dissolve the egg shell. Place the egg in enough vinegar to submerge it for at least 24 hours.

27. Copy and complete the following table.

| Step | Observations |
|---|---|
| Submerge egg in 10% salt solution. | |
| Submerge egg in distilled water. | |

28. Answer questions 1 to 5 of "Questions" on page 280 of the textbook.


Check your answers with those on page 71.

From the preceding activity you can see that the concentration gradient is reversible. When the concentration of particles that are able to cross the semi-permeable membrane is higher on the inside, the substance will move from inside to outside. The movement is from outside to inside if the concentration is higher on the outside.

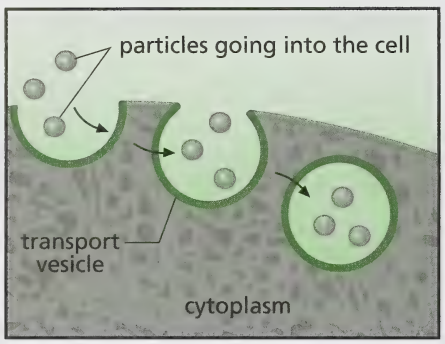
In some cases, molecules or particles that need to be taken in or moved out of the cell are too large for any of the previous processes. Large molecules and particles can be taken in by **endocytosis** and excreted by **exocytosis**.

Turn to page 281 of the textbook and read "Endocytosis and Exocytosis."

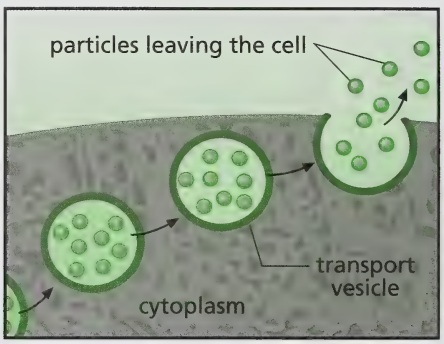
**endocytosis:** a process of moving molecules or particles into a cell using a vesicle formed from the cell membrane

**exocytosis:** a process of removing molecules or particles from a cell through vesicles that fuse to the cell membrane and rupture

**Endocytosis**




**Exocytosis**




29. Describe endocytosis and exocytosis.


Check your answer with the one on page 71.

For more information on endocytosis and exocytosis, first read "Research" at the top of page 281 of the textbook. Then, if possible, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Page 281. You will find a number of animations on endocytosis and exocytosis as well as diffusion, osmosis, and active transport.

## Looking Back

You have now covered all the concepts for this lesson. You described how the cell membrane moves molecules and particles in and out of the cell.

30. Answer questions 2, 3, 4, and 8 of "Check and Reflect" on page 283 of the textbook.

Check Check your answers with those on page 71.

Go to ... Go to pages 3 to 5 of Assignment Booklet 3B and answer questions 10 to 18.

## Glossary

**active transport:** the movement of molecules or ions across a semi-permeable membrane against the concentration gradient that requires energy

**carrier protein:** a protein present in the cell membrane that binds to a specific molecule and transports it across the membrane

**channel protein:** a protein present in the cell membrane that forms a passageway for specific molecules or ions to pass through

**concentration gradient:** the difference within a given area or region of the highest and lowest concentrations of a substance

**diffusion:** the spontaneous movement of particles from an area of higher concentration to an area of lower concentration

**endocytosis:** a process of moving molecules or particles into a cell using a vesicle formed from the cell membrane

**equilibrium:** a state of balance between opposite actions

**exocytosis:** a process of removing molecules or particles from a cell through vesicles that fuse to the cell membrane and rupture

**facilitated diffusion:** diffusion across a semi-permeable membrane through carrier proteins; does not require energy

**hypertonic:** having a higher concentration of solute than another solution

**hypotonic:** having a lower concentration of solute than another solution

**isotonic:** having the same concentration of solute as another solution

**osmosis:** the diffusion of water across a selectively permeable membrane

**passive transport:** movement that does not require energy

**semi-permeable membrane:** a membrane that allows only certain particles to pass through; can be naturally or synthetically produced

## Suggested Answers

1. Substances that enter and leave the cell are regarded as particles.

2. The particle model of matter states that all matter is made up of particles that are attracted or bonded to one another, that the particles are constantly moving, and that the particles have spaces between them. From this you can hypothesize that particles can move through a cell membrane, which is also made up of particles.

3. The coffee aroma molecules spread out until they are equally spaced throughout the room.

4. a. Rate of diffusion is the relative movement of particles in response to the concentration gradient.

   b. Rate of diffusion can be changed by adding or removing energy, thereby increasing or decreasing molecular movement.

5. *Concentration gradient* is the difference in concentration of a particular substance in two areas.

6. Movement of a substance through diffusion is called passive transport because no energy has to be added for it to occur.

7. The cell membrane is considered to be a selectively permeable membrane because it allows only certain particles through, not all particles.

8. The passage of materials through the cell membrane are determined by the size of the molecules, the charge of the molecules, and whether they are soluble in lipids.

9. Carbon dioxide leaves a cell because the concentration inside the cell is higher than outside the cell. Oxygen enters the cell because the concentration of oxygen is higher outside the cell than inside the cell.

10. Answers will vary. A sample hypothesis is given.

    Some substances will go into the bag and some substances will come out of the bag. The plastic bag behaves like a semi-permeable membrane that allows some particles to pass in or out.

11. Your table should be similar to the following.

| Container | Observations |
|---|---|
| Test Tube 1 | no change |
| Test Tube 2 | water turns pale gold after adding iodine |
| Test Tube 3 | no change, remains cream coloured |
| Test Tube 4 | starch solution turns black after adding iodine |
| starch solution in bag | starch solution turns black, indicating that iodine penetrated the bag |
| Beaker with water and iodine | no black colour shows up in the beaker with iodine, indicating that no starch left the bag |

12. a. **Textbook questions 1 to 4 of "Analyzing and Interpreting," p. 276**

    1. Adding iodine to Test Tube 2 turned the water pale gold. Adding iodine to Test Tube 4 turned the solution black. These results show that iodine turns black in the presence of starch. This makes iodine an indicator for the presence of starch.

    2. Test Tubes 1 and 3 are controls. Test Tube 1 shows that water stays the same throughout the experiment when nothing is added to it. Test Tube 3 shows that a starch solution is cream coloured.

    3. When the bag of starch is placed in the beaker of water and iodine, initially the water and iodine in the beaker are pale gold and the starch in the bag is cream coloured. The water and iodine in the beaker remained pale gold, indicating that no starch passed through the bag. The starch inside the bag turned black, indicating that iodine passed through the bag. There is a concentration gradient for iodine molecules to move from outside the bag to inside the bag. Iodine molecules must be small enough to move through the semi-permeable, plastic membrane. There is a concentration gradient for starch molecules to move from inside the bag to the water and iodine solution outside the bag. Starch molecules must be too large to move through the semi-permeable, plastic membrane.

    4. The bag containing the starch solution became more tightly stretched over time and showed a volume of liquid inside the bag. Since there was only a dropper full of iodine in the beaker, this indicates that water molecules and iodine molecules entered the bag.

    b. **Textbook question 5 of "Forming Conclusions," p. 276**

    5. Answers will vary. A sample answer is given. The plastic membrane is semi-permeable, and iodine and water molecules were able to enter the bag while starch molecules did not leave the bag. The hypothesis was correct regarding some substances going into the bag, but not correct about substances coming out of the bag.

13.

| Container | Observations |
|---|---|
| Test Tube 1 | The solution is clear. |
| Test Tube 2 | The water turns pale gold colour after the iodine is added. |
| Test Tube 3 | The solution is milky white or cream coloured. |
| Test Tube 4 | The starch solution turns black after iodine is added. |
| Test Tube 5 | The solution is pale yellow. |
| Test Tube 6 | The solution is pale black. |
| beaker with water and iodine | No black colour shows up in the beaker with iodine. |
| starch solution in bag | The starch solution turns black. |

14. The solution in the beaker did not change colour; it remained the pale yellow. The solution in the plastic bag changed from a milky white, or cream coloured, to a pale black.

15. The change in colour indicates that iodine passed through the plastic bag into the starch solution. There was no change in colour in the solution in the beaker, so starch did not pass through the plastic bag into the iodine solution.

16. The student in the video said that nothing would pass through the plastic bag. The results indicate that the iodine did pass through the plastic bag and entered the starch solution. So, the results do not support the student's hypothesis. **Note:** It is difficult to tell from the video if the volume of the bag increased, showing that water moved into the bag.

17. Test Tubes 1 and 3 were controls for the experiment.

18. Five key points related to concentration gradients are

    - must involve different concentrations
    - in cells, different concentrations may be separated by a membrane
    - involves molecules or ions of a single type
    - drives diffusion and osmosis
    - different molecules move along their concentration gradient independently of other molecules

19. The plastic bag behaved like a semi-permeable membrane because it has pores that are large enough to allow small molecules and ions through.

20. The water flows from left to right because the addition of solute on the right side makes the water concentration lower on the right side relative to the left side. In osmosis, water flows from an area of higher water concentration to an area of lower water concentration.

21. *Hypertonic* refers to a solution with a higher solute concentration outside a cell than inside the cell.

    *Isotonic* refers to a solution with the same solute concentration outside a cell as inside the cell.

    *Hypotonic* refers to a solution with a lower solute concentration outside a cell than inside the cell.

22. **Textbook questions 1 to 4 of "Skill Practice: Linking Conclusions to Hypotheses," p. 279**

    1. Vegetables, like carrots and celery, become crispy when placed in a container of water because they absorb water. Normally, the vegetables are placed in water while still crisp and, thus, retain their water and maintain their crispness.

    2. a. A zero mass change would indicate that no water was absorbed or lost by the potato slices. You could infer that the solution the potato slices were placed in was isotonic relative to the contents of the potato cells.

       b. A positive percent change in mass indicates that more water entered the potato slices than left. You can infer that the solution the potato slices were placed in was hypotonic relative to the contents of the potato cells.

       c. A negative percent change in mass indicates that less water entered the potato slices than left. You can infer that the solution the potato slices were placed in was hypertonic relative to the contents of the potato cells.

    3. The graph shows that potato slices lose mass in a hypertonic solution, show no change in mass in an isotonic solution, and gain mass in a hypotonic solution.

    4. The hypothesis was accepted. Vegetables remain or become crispy when placed in water because they retain or gain water.

23. *Channel proteins* are proteins that create pores or channels in the cell membrane through which small, water-soluble molecules can pass.

    *Carrier molecules* are molecules that attach to larger molecules and move these molecules through the cell membrane by physically changing shape.

    *Facilitated diffusion* is diffusion that involves a protein assisting the movement of a molecule that is responding to a concentration gradient.

24. a. Active transport is the movement of molecules against the concentration gradient. Active transport requires the input of energy to move the molecules from one area to another.

    b. The energy for active transport is produced from adenosine triphosphate (ATP) in the cell by the mitochondria. The ATP is produced from glucose through a series of chemical reactions.

    c. Active transport is different from diffusion and facilitated diffusion in that active transport moves molecules against the concentration gradient and requires energy.

25. Your completed table should be similar to the following.

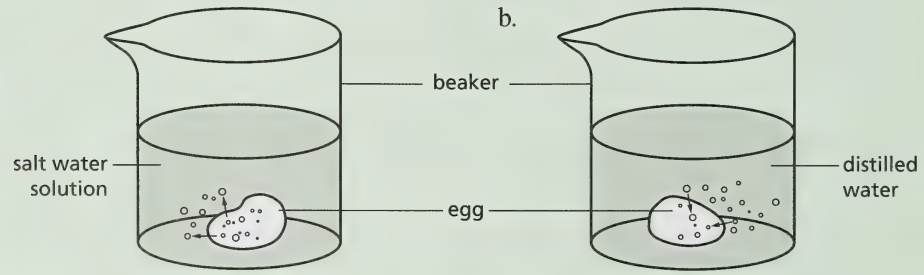
| Step | Starting Mass of Egg (g) | Final Mass of Egg (g) | Observations |
|---|---|---|---|
| Submerge in 10% salt solution. | 56.3 g | 48.6 g | The membrane of the egg wrinkled, and the egg appeared to decrease in size. |
| Submerge in distilled water. | 48.6 g | 55.2 g | The membrane of the egg became smooth again, and the egg appeared to increase in size. |

26. **Textbook questions 1 to 5 of "Questions," p. 280**

1. When the egg was placed in the salt solution, the membrane began to loosen and wrinkle. After 8 min, it appeared that the egg was smaller in size. The salt solution must have had a lower concentration of water than the inside of the egg, so water moved from inside the egg to the salt water solution.

2. After the egg was moved to the distilled water for about 15 min, it appeared to increase in size and the membrane became smooth. The contents of the egg had less water in it than the surroundings, so water moved from outside the egg to inside the egg . This increased the mass and volume of the egg.

3. a.




The arrows show water molecules moving from inside the egg to the outside.

The arrows show water molecules moving from outside to inside the egg.

4. Particles move from an area of higher concentration to an area of lower concentration. In this case, the concentration of water molecules was higher inside the egg at the start, so water molecules moved from inside to outside. After the egg was moved from the salt solution to the distilled water, the concentration of water molecules was higher on the outside of the egg. This caused the water molecules to move from outside the egg to inside the egg.

5. Water is able to move across the egg membrane by diffusion. The sodium and chlorine ions require a transport protein to move across the membrane. The results of the experiment with the egg in a 10% salt solution indicate that water is moving out of the egg since the egg membrane shrivels. If salt could move across the membrane, both salt and water would move across until equilibrium is reached.

27. Your completed table should be similar to the following.

| Step | Observations |
|---|---|
| Submerge egg in 10% salt solution. | The membrane of the egg wrinkled, and the egg appeared to decrease in size. |
| Submerge egg in distilled water. | The membrane of the egg became smooth again, and the egg appeared to increase in size. |

28. Refer to the answer to question 26.

29. In endocytosis, the cell membrane folds and forms a sac that surrounds the molecules or particles that need to be brought into the cell. The sac then becomes a vesicle inside the cell.

    In exocytosis, molecules or particles to be excreted are transported within a vesicle that fuses with the cell membrane. The vesicle then ruptures, releasing the contents outside the cell.

30. **Textbook questions 2, 3, 4, and 8 of "Check and Reflect," p. 283**

    2. The process of diffusion occurs as a result of the natural movement of particles from an area of higher concentration to an area of lower concentration.

       Facilitated diffusion is the movement of large particles across the membrane by carrier molecules that attach to these particles and physically move them across the membrane. Facilitated diffusion is in response to the concentration gradient.

       Active transport is the movement of particles from an area of lower concentration to an area of higher concentration and requires the input of energy.

       Diffusion is necessary to the cell as it does not require energy. Facilitated diffusion also does not require energy, but it is useful to the cell as large particles can be moved across the membrane. Active transport is necessary to the cell as the movement is against the concentration gradient.

    3. A concentration gradient is a difference in concentration between an area of higher concentration and an area of lower concentration of a particular substance. Equilibrium is a state of balance resulting in no net movement of particles.

    4. To keep the celery crisp, cut the end of the celery stalk and immerse it into water. The celery will absorb water as necessary to maintain its crispness.

    8. a. The salt or syrup solutions would be hypertonic to the micro-organisms, resulting in a loss of water by the micro-organisms.

       b. The effect would be that the micro-organisms would lose so much water that they eventually die.

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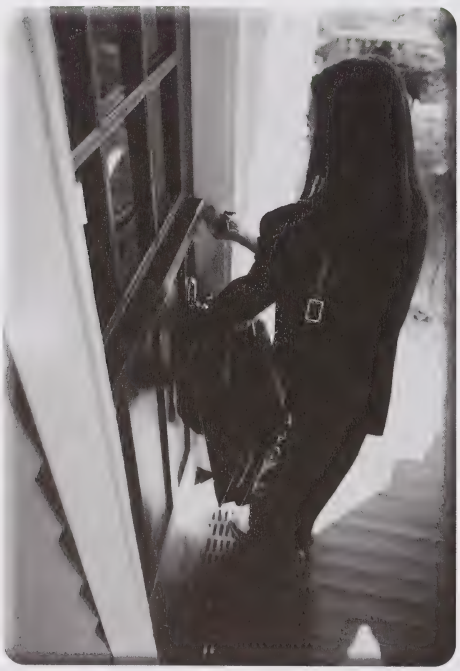
# Lesson 3

## Applications of Cellular Transport in Industry and Medicine



When you insert your key into the lock on the door of your house, you are able to unlock and open the door and enter your house. If you go to your neighbour's house and try your key, you will find it won't unlock the door. A key works by having parts that are shaped in a certain way that allows it to work only for that lock.

Similarly, cell membranes have proteins that have specific shapes. Often, viruses have parts with specific shapes that fit the specific shape of the protein on the cell membrane. If the virus has the part with the correct shape, it can gain entry into the cell through the protein. Scientists, today, are using technology to find ways of having cells combat diseases that have no cure by changing the way proteins on the cell membrane work.

**recognition protein:** a protein embedded in the cell membrane that allows cells to recognize each other and foreign materials

**receptor protein:** a protein that binds with certain molecules to bring them into the cell

Turn to pages 284 and 285 of the textbook and read the introduction to "Applications of Cellular Transport in Industry and Medicine" and the information in "Membrane Proteins and Disease." You will examine **recognition proteins** and **receptor proteins** and how viruses can be blocked from entering a cell. Study Figure C2.24 closely.

1. What are membrane technologies?

2. Describe recognition proteins and receptor proteins.

3. How has the ability of some proteins to use specific binding reactions turned against humans?

4. Explain how scientists think they might be able to stop HIV.

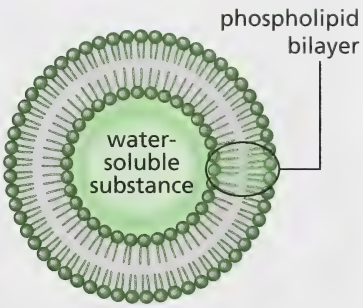
5. Describe how new treatments for cancer might work.


Check your answers with those on pages 76 and 77.

**liposome:** a fluid-filled sac surrounded by a phospholipid bilayer that is identical to a human cell membrane

Another application of cellular transport in medicine is the use of synthetic membranes. A synthetic membrane is identical to a human cell membrane. It is used to make **liposomes** that can be used to deliver medication to specific sites and for extended periods of time.

**Synthetic Membrane**




Read the information in "Synthetic Membrane Technology" on page 285 of the textbook.

6. a. How can liposomes carry both water-soluble and fat-soluble medications?
   b. Describe two advantages of using liposomes in HIV and cancer treatment.
   c. How are liposomes used in gene therapy to destroy cancer cells?

7. Read "*info*BIT" at the bottom of page 285 of the textbook. What are synthetic vaccines?


Check your answers with those on page 77.

For more information on synthetic membrane technology, visit

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Page 285. Listed are links to some informative websites.

**insulin:** a small protein produced in the pancreas that influences the movement of glucose into cells

Another area of study relating to the cell membrane is the study of the transport of protein hormones—one of which is **insulin**. Insulin is produced in the pancreas and sent through the bloodstream to receptor proteins of tissues, including liver, muscle, and fat. Insulin binds to receptor proteins in the cell membrane and stimulates the rate of movement of glucose into the cell.

Read "Transport of Protein Hormones" on page 286 of the textbook.

8. How is the production of insulin initiated?

9. Read "*info*BIT" on page 286 of the textbook. What is the difference between the "diabetes pill" used for Type II diabetes and insulin injections used for Type I diabetes?

Check your answers with those on page 77.

**hemodialysis:** a process by which blood is circulated outside the body to a dialysis machine, which cleanses the blood and returns it to the body

**peritoneal dialysis:** a process that uses the membrane that lines the abdominal cavity to remove waste products from the blood by diffusion into a dialysate fluid

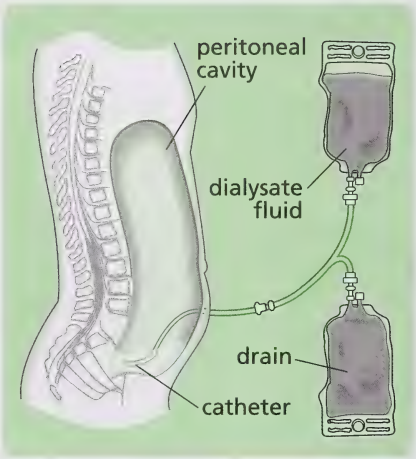



**Figure 2.2:** Peritoneal dialysis

**Hemodialysis** is a treatment for kidney failure that involves a special machine and has to be done in a medical facility. Blood is removed from the body and circulated through a dialysis machine. **Peritoneal dialysis** is a treatment for kidney failure that involves a membrane, called the peritoneum, that lines the abdominal cavity. In peritoneal dialysis, a plastic tube is inserted into the abdominal cavity and sterile dialysate fluid is pumped into the cavity. The toxins and wastes diffuse across the membrane into the dialysate fluid. When the cleansing fluid is saturated with wastes, it is removed from the cavity.

Peritoneal dialysis may have to be done several times a day; but it has the advantage that it can be done at home.

For more information, read "Peritoneal Dialysis" on pages 286 and 287 of the textbook.

10. Why do some people need to have dialysis treatments?

11. On what scientific principles—those covered in the previous lesson—is dialysis based?

12. Describe hemodialysis.

13. What is one advantage and one disadvantage of each type of treatment?

Check your answers with those on page 77.

Use any of the Internet's search engines to find more information on peritoneal dialysis and hemodialysis.

**desalination:** the process by which salt is removed from salt water

Membrane technology is also used in industrial applications. One area is that of water **desalination**. Desalination is of particular importance in Antarctica, where fresh water is scarce.

Turn to pages 287 and 288 of the textbook and read "Reverse Osmosis."

14. a. How is reverse osmosis different from osmosis?

    b. How is reverse osmosis affected by charged particles?

    c. Name a device used in many homes that works on the principle of reverse osmosis.

Check Check your answers with those on page 78.

Use the Internet to research membrane technology. Start by visiting

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Page 288. Click on *Membrane Technology in the Dairy Industry* for information about the latest membrane technology in this industry. Also, feel free to use any of the Internet's search engines to find other informative sites on membrane technology.

15. a. Name three applications of membrane technology.
    b. Name three ways membrane technology is used in the dairy industry.

Check Check your answers with those on page 78.

## Looking Back


16. Answer questions 1, 4, 6, and 8 of "Check and Reflect" on page 288 of the textbook.

Check Check your answers with those on pages 78 and 79.

Go to ... Go to pages 5 to 7 of Assignment Booklet 3B and answer questions 19 to 27.

## Glossary

**desalination:** the process by which salt is removed from salt water

**hemodialysis:** a process by which blood is circulated outside the body to a dialysis machine, which cleanses the blood and returns it to the body

**insulin:** a small protein produced in the pancreas that influences the movement of glucose into cells

**liposome:** a fluid-filled sac surrounded by a phospholipid bilayer that is identical to a human cell membrane

Liposomes are used to deliver medication to diseased cells without affecting normal cells.

**membrane technology:** research into the development and use of synthetic membranes in various industrial and medical applications

**peritoneal dialysis:** a process that uses the membrane that lines the abdominal cavity to remove waste products from the blood by diffusion into a dialysate fluid

**receptor protein:** a protein that binds with certain molecules to bring them into the cell

**recognition protein:** a protein embedded in the cell membrane that allows cells to recognize each other and foreign materials

## Suggested Answers

1. Membrane technologies are the areas of research into the use of synthetic materials to create membranes that will mimic natural membranes.

2. Recognition proteins are proteins embedded in the cell membrane and allow cells to recognize each other as well as foreign materials. Receptor proteins are proteins that bind with certain molecules to bring them into the cell.

3. Some diseases, like HIV, use a specific binding reaction to target human cells and enter the cell by endocytosis. Other bacteria or viruses attach to the outside of the human cell and trigger different activities inside the cell.

4. Scientists think they might be able to stop HIV by covering the receptors the HIV virus attaches to. This is similar to filling the key hole of a lock with some substance so the key will not fit.

5. New treatments for cancer involve identifying the unique proteins of cancer cells and developing drugs specific to these proteins. The idea is that the drugs would affect only the cancer cells and not healthy cells. Other treatments involve stimulating the immune system to target and destroy only cancer cells by identifying their unique proteins.

6. a. Liposomes can carry water-soluble medications in the fluid-filled centre and fat-soluble medications in the membrane layer.

   b. One advantage is that liposomes can circulate in the bloodstream longer than the medication on its own can, allowing for longer, sustained treatment. Another advantage is that liposomes can concentrate themselves at the site of the tumor or infection and deliver the drug directly to the targeted cells.

   c. In gene therapy, liposomes contain DNA that is to be injected into cancer cells. Each liposome has a molecule on its surface that fits on to the surface of certain cancer cells so only cancer cells are targeted. The DNA introduced into cancer cells causes the production of toxins that kill these cells. This research is still in its early stages and requires more study before being implemented.

7. Synthetic vaccines use molecules that resemble parts of the cell membrane of the disease-causing cells, thus targeting only the disease-causing cells.

8. The production of insulin is initiated when specialized cells in the pancreas detect levels of glucose in the bloodstream.

9. The "diabetes pill" does not contain actual insulin like the injection for Type I diabetes. The "diabetes pill" contains a substance that stimulates the pancreas of the person with Type II diabetes to produce insulin. Without this stimulation, the person's pancreas does not produce enough insulin. Other types of "diabetes pills" make the body more sensitive to insulin that is produced.

10. People whose kidneys have failed need dialysis treatments.

11. Dialysis is based on diffusion, osmosis, and the concentration gradient.

12. Hemodialysis is a type of dialysis treatment in which the blood is passed through a special machine that cleanses the blood using a dialysate fluid. A person needing this procedure must go into a health facility to have it performed.

13. An advantage of peritoneal dialysis is that the treatments can be done at home and the patient can carry on with some activities while it is done. A disadvantage of peritoneal dialysis is that it must be done several times a day and the person must schedule time to do it. Because of this, a person may not always do it on a regular basis.

    An advantage of hemodialysis is that time is scheduled in a health-care facility and a person is more likely to have the treatments done on a regular basis. A disadvantage of hemodialysis is that the person cannot move around or do anything during this type of dialysis. The dialysis treatment can take three to five hours at a time, three times a week.

14. a. In osmosis, the solvent enters the solution along the concentration gradient. That is, the water moves from an area of higher water concentration to an area of lower water concentration. In reverse osmosis, the solvent exits the solution against the concentration gradient. That is, the water moves from an area of lower water concentration to an area of higher water concentration. Osmosis does not require energy, whereas reverse osmosis does require energy to force the water through the membrane.

    b. The larger the particle and the greater the charge, the less likely the particle is to move through the membrane.

    c. Many water filtration systems in homes work on the principle of reverse osmosis.

15. a. Applications of membrane technology include membranes for water purification, dialysis, controlled delivery of medication, removing water from natural gas, separating hydrocarbons from air, producing flavours for foods and beverages, processing milk into cream and other components, and filtration systems used in making cheese.

    b. Membrane technology is used in the dairy industry in the following areas:

        - skim milk concentration
        - whey processing
        - lactose recovery
        - evaporator condensate recovery
        - fermentation and biotechnology
        - brine clarification
        - cleaning chemicals recovery
        - specialty products
        - salt whey processing
        - mozzarella cooker water recovery

16. **Textbook questions 1, 4, 6, and 8 of "Check and Reflect," p. 288**

    1. Dialysis works on the principle that molecules are in continuous motion and will move along the concentration gradient from a higher concentration to a lower concentration. Particles are also able to move through a semi-permeable membrane. Any substance that has a lower concentration in the dialysate fluid and a higher concentration in the blood will move from the blood to the dialysate fluid. Any substance that must be kept in the blood must have an equal concentration of the substance in the dialysate fluid so there is no tendency for the substance to leave the blood.

4. Differences between peritoneal dialysis and hemodialysis are summarized in the following table.

| Peritoneal Dialysis | Hemodialysis |
|---|---|
| • uses a natural membrane<br>• cleaning takes place inside the body<br>• can be performed at home<br>• allows patient to move around and perform some activities during the process | • uses a synthetic membrane<br>• blood must be circulated outside the body for cleaning<br>• patient must go to a health-care facility at a scheduled time<br>• process does not allow patient to move around |

6. Membrane binding of insulin to a target cell stimulates the movement of glucose into the cell as well as a number of other changes.

8. Limitations may include the following.

   - The lock-and-key concept for protection against the entry of the HIV virus into to the cell may not be specific enough and may block needed substances from entering the cell.
   - If recognition proteins are not specific enough to the HIV virus or cancer cells, healthy cells might be targeted and killed as well.
   - In cancer treatment, liposomes may deliver medication to cancer cells as well as healthy cells, making gene therapy uncontrollable.
   - In kidney disease, there are problems with keeping the fluids balanced at the right level and with the gain or loss of water.

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# Lesson 4

## Is Bigger Better?

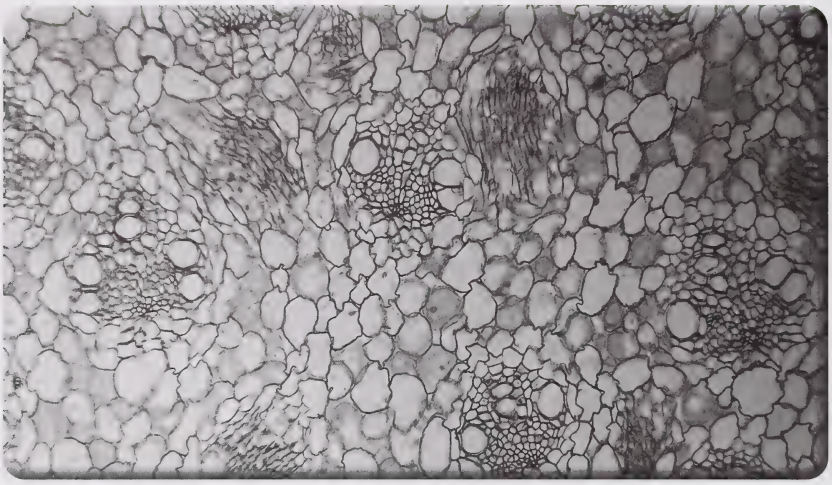


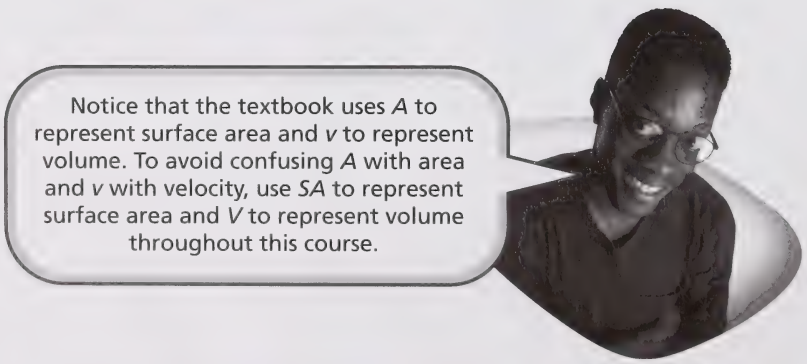
**Figure 2.3:** Plant cells

Figure 2.3 shows that plant cells are small. Most cells, plant or animal, are small. Large plants and animals are made up of millions of cells. Why aren't large plants or animals made up of large cells?

**surface area to volume ratio:** a ratio between the total surface area of an object and its volume

Part of the reason why large plants or animals are not made of large cells lies in the **surface area to volume ratio** of the cell. To be efficient and to be able to carry on all the life processes, a cell must have a large surface area to volume ratio.

You will see how the surface area to volume ratio is affected by size. Turn to page 289 of the textbook and read "The Ratio of Surface Area to Volume." Work through Example Problem C2.1 carefully.



1. How does a larger cell affect the transport of molecules around the cell?

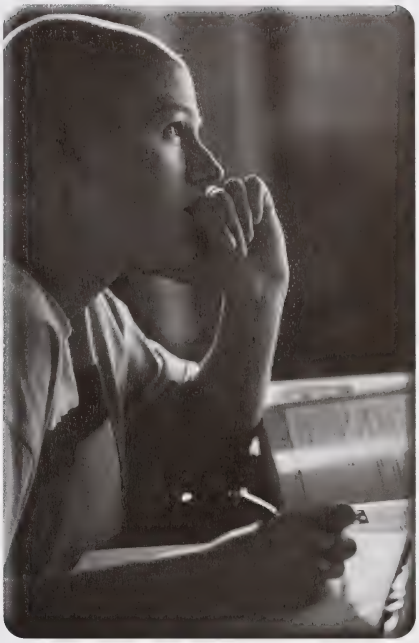
2. What has to increase if a cell is to maintain its ability to transport molecules in and out of the cell?

3. Refer to Example Problem C2.1 on page 289 of the textbook.

   a. How is the surface area to volume ratio calculated?

   b. What happens to the surface area to volume ratio as the size of the cube (cell size) increases?

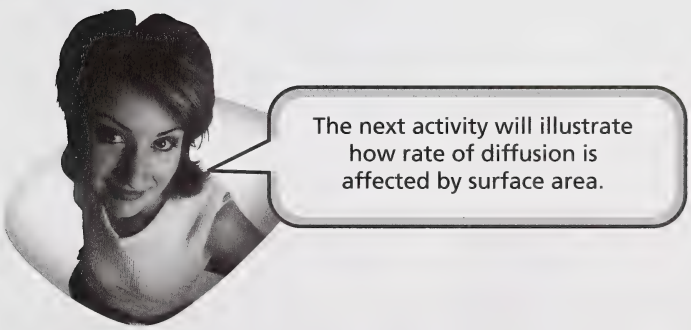
   c. How does this change in surface area to volume ratio compare with the requirement stated in question 2?



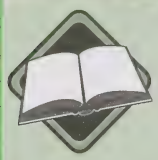
4. Answer questions 1.a. and 3 of "Practice Problems" on page 289 of the textbook.

5. What conclusion can you make about the surface area to volume ratio and cell transport efficiency?


Check your answers with those on pages 87 and 88.



## Inquiry Lab



# Is Bigger Better?

Read the entire activity on pages 290 and 291 of the textbook.

6. State a hypothesis indicating how you think the rate of diffusion will be affected by differences in the surface area to volume ratios of cells.


Check your answer with the one on page 88.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Carefully follow the procedure on pages 290 and 291 of the textbook.

**Pay special attention to the safety precautions mentioned, especially those regarding hydrochloric acid and the gelatin cubes.**

7. Copy and complete the following tables with your observations.

| Cube Size | Side Length $s$ (cm) | Surface Area of 1 Cube ($cm^2$) | Total Number of Cubes | Total Surface Area $SA$ ($cm^2$) | Total Volume $V$ ($cm^3$) | Surface Area to Volume Ratio |
|---|---|---|---|---|---|---|
| steps 1 to 4 | 4 | | | | | |
| steps 5 to 7 | 2 | | | | | |
| steps 9 and 10 | 1 | | | | | |

| Time for Colour to Change from Pink to Colourless | |
|---|---|
| steps 1 to 4 | |
| steps 5 to 7 | |
| steps 9 and 10 | |

8. Answer the following on page 291 of the textbook.

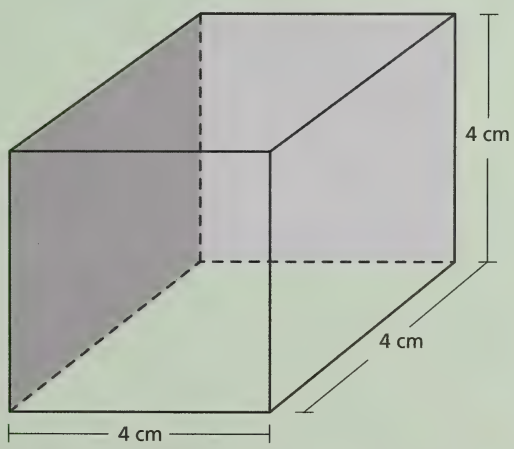
   a. questions 1 to 5 of "Analyzing and Interpreting"
   b. question 6 of "Forming Conclusions"
   c. question 8 of "Extending"


Check your answers with those on pages 88 to 90.

## Part B

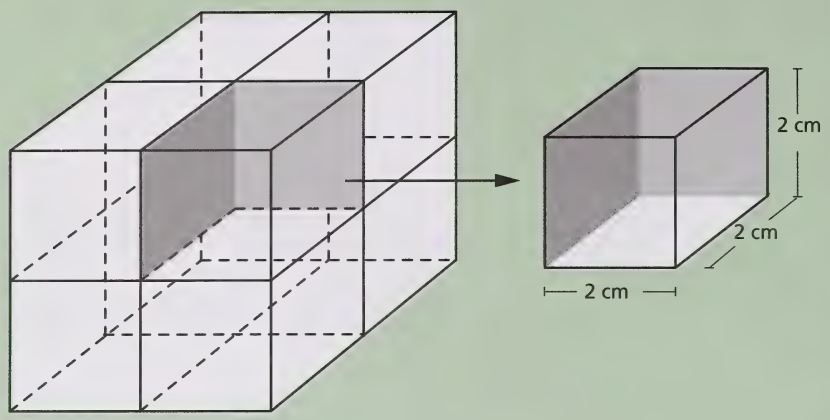
Use the following information to complete the tables in question 7 and to answer question 8 in Part A.

### Steps 1 to 4



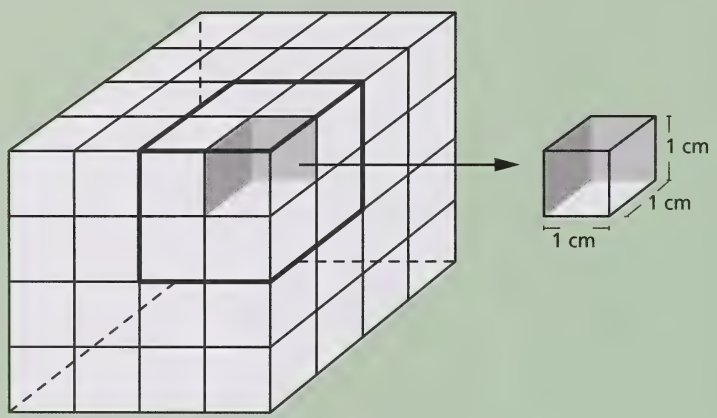

**Changes from Pink to Colourless:** 52 min

### Steps 5 to 7




**Changes from Pink to Colourless:** 16 min

### Steps 9 and 10




**Changes from Pink to Colourless:** 6 min

In the preceding activity you found that the surface area to volume ratio affects the rate of diffusion in a gelatin cube. You related this to efficiency of diffusion and transport in cells.

For more information on how the size and shape of organisms affect their survival, read "The Size and Shape of Organisms" and "Maximizing Potential" on pages 292 and 293 of the textbook.

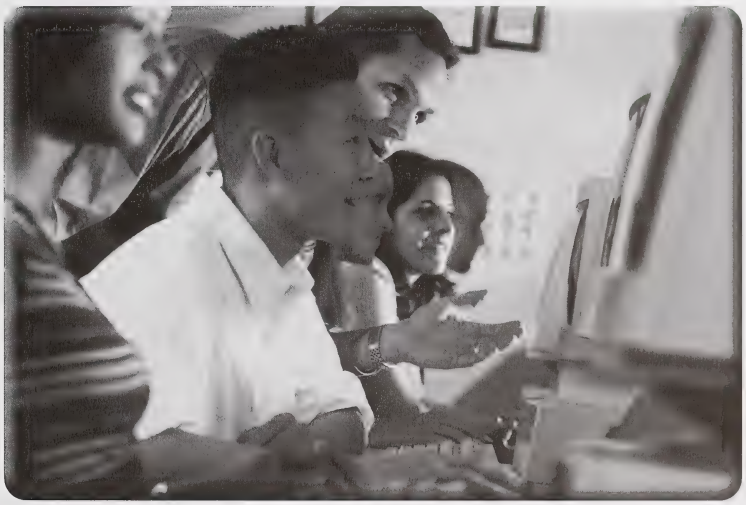
9. How does the shape of a red blood cell affect its function?

10. How does a small cell size aid passive transport of nutrients into and out of a cell?

11. How have multicellular organisms developed to reduce the dependence on diffusion?

12. Describe three types of specialized structures that make use of large surface area to volume ratios.

Check your answers with those on page 90.



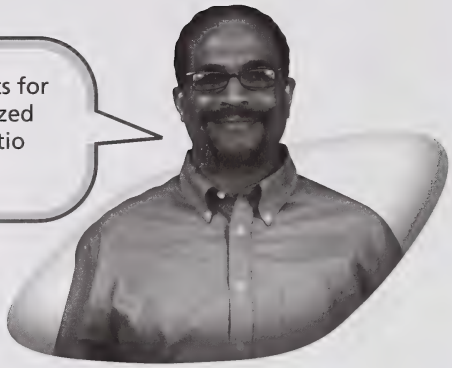
If you wish to investigate the range of surface area to volume ratios for several different types of human cells and plant cells, start by visiting

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Page 293. You will be given a list of informative links from which to start your research.

## Looking Back

You have just covered all the concepts for this lesson. You observed and analyzed how the surface area to volume ratio relates to cell size and efficiency.



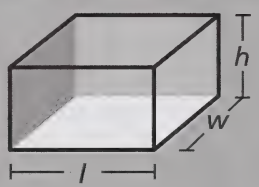
13. Answer the following on pages 293 and 294 of the textbook.

    a. questions 1, 2, 3, and 5 of "Check and Reflect"
    b. questions 16 and 17 of "Section Review"

**Note:** For question 16, the formulas for the surface area ($SA$) and volume ($V$) of a rectangular prism are

$$SA = 2(l \times w) + 2(l \times h) + 2(h \times w)$$

$$V = l \times w \times h$$




Check your answers with those on pages 90 and 91.

Go to page 8 of Assignment Booklet 3B and answer questions 28 to 31.

## Glossary

**surface area:** the area of the outside shell of an object

**surface area to volume ratio:** a ratio between the total surface area of an object and its volume

**volume:** the amount of space inside an object

# Suggested Answers

1. A larger cell requires more molecules to be transported around and over larger distances across the cell.

2. The surface area has to increase if a cell is to maintain its ability to transport molecules in and out of the cell.

3. a. The surface area is equal to 6 times the square of the length of a side, $s$, of the cube.

   $SA = 6s^2$

   The volume of the cube is equal to the length of a side, $s$, cubed.

   $V = s^3$

   The surface area to volume ratio is calculated by dividing the surface area by the volume.

   b. The surface area to volume ratio decreases as the size of the cube (cell size) increases.

   c. A decreasing surface area to volume ratio is opposite to what is required for a cell to maintain efficiency.

4. **Textbook questions 1.a. and 3 of "Practice Problems," p. 289**

   1. a. surface area to volume ratio of a cube $= \frac{6}{s}$

   $= \frac{6}{3.5}$

   $= 1.7$ ← 2 significant digits

**Note:** You can check this ratio by calculating the surface area and volume separately and then dividing the surface area by volume.

Surface area, $SA = 6s^2$

$= 6(3.5 \text{ cm})^2$

$= 73.5 \text{ cm}^2$

Volume, $V = s^3$

$= (3.5 \text{ cm})^3$

$= 42.875 \text{ cm}^3$

Surface area to volume ratio $= \frac{SA}{V}$

$= \frac{73.5}{42.875}$

$= 1.7$ ← 2 significant digits

3. Surface area of a sphere, $SA = 4\pi r^2$

   Volume of a sphere, $V = \frac{4}{3}\pi r^3$

   $$\text{Surface area to volume ratio} = \frac{SA}{V}$$
   $$= \frac{4\pi r^2}{\frac{4}{3}\pi r^3}$$
   $$= \frac{3}{r}$$

   a. $\frac{SA}{V} = \frac{3}{r}$
   $= \frac{3}{4.3}$
   $= 0.70$

   b. $\frac{SA}{V} = \frac{3}{r}$
   $= \frac{3}{8.6}$
   $= 0.35$

5. The greater the surface area to volume ratio, the more efficient cell transport will be.

6. The greater the surface area to volume ratio, the greater the rate of diffusion into cells.

7. Your completed tables should be similar to the following.

| Cube Size | Side Length $s$ (cm) | Surface Area of 1 Cube ($cm^2$) | Total Number of Cubes | Total Surface Area $SA$ ($cm^2$) | Total Volume $V$ ($cm^3$) | Surface Area to Volume Ratio |
|---|---|---|---|---|---|---|
| steps 1 to 4 | 4 | 96 ($= 6 \times 4^2$) | 1 | 96 | 64 | 1.5 |
| steps 5 to 7 | 2 | 24 ($= 6 \times 2^2$) | 8 | 192 | 64 | 3.0 |
| steps 9 and 10 | 1 | 6 ($= 6 \times 1^2$) | 64 | 384 | 64 | 6.0 |

| Time for Colour to Change from Pink to Colourless | |
|---|---|
| steps 1 to 4 | 52 min |
| steps 5 to 7 | 16 min |
| steps 9 and 10 | 6 min |

8. a. **Textbook questions 1 to 5 of "Analyzing and Interpreting," p. 291**

1. When the length of the side of each cube is halved, the surface area to volume ratio is doubled.

2. **Steps 1 to 4**

$$\text{rate of diffusion} = \frac{\text{total volume}}{\text{time}}$$

$$r = \frac{64\ \text{cm}^3}{52\ \text{min}}$$

$$= 1.2\ \text{cm}^3/\text{min}$$

**Steps 5 to 7**

$$\text{rate of diffusion} = \frac{\text{total volume}}{\text{time}}$$

$$r = \frac{64\ \text{cm}^3}{16\ \text{min}}$$

$$= 4.0\ \text{cm}^3/\text{min}$$

**Steps 9 and 10**

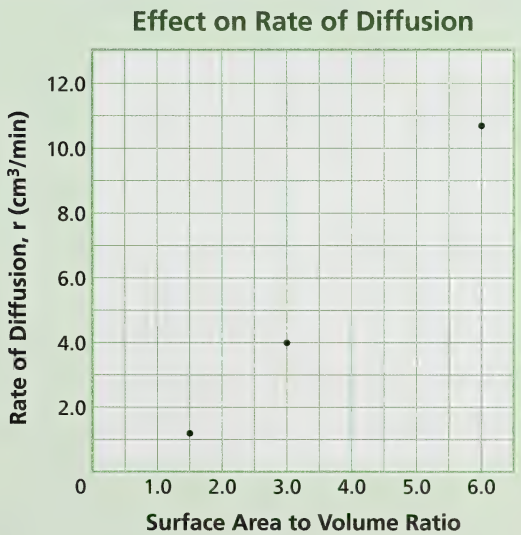
$$\text{rate of diffusion} = \frac{\text{total volume}}{\text{time}}$$

$$r = \frac{64\ \text{cm}^3}{6\ \text{min}}$$

$$= 10.7\ \text{cm}^3/\text{min}$$

3. Decreasing the size of the cubes while increasing the number of cubes increases the rate of diffusion.

4. Your graph should be similar to the following.




5. As the surface area to volume ratio increases, the rate of diffusion increases.

b. **Textbook question 6 of "Forming Conclusions," p. 291**

6. The greater the surface area to volume ratio, the greater the rate of diffusion. This analysis supports the hypothesis. This also supports that the smaller the size of the cell, the more efficient the transport of materials within the cell will be.

c. **Textbook question 8 of "Extending," p. 291**

8. Small cells have a greater surface area to volume ratio, which results in high rates of diffusion. Also, distances for transport of materials in the cell is small, which makes the cell more efficient.

9. The biconcave shape of a red blood cell gives it the largest surface area possible for its volume. The large surface area to volume ratio in red blood cells results in an efficient exchange of $O_2$ and $CO_2$ in the lungs and to the body cells.

10. A small cell size aids passive transport because water, gases, and nutrients are able to get into and out of various parts of the cell quickly.

11. Multicellular organisms have circulatory, digestive, and respiratory systems to help in the transport of materials to cells in various areas of the body. Large plants have transports systems, such as xylem and phloem, to help transport materials to various areas of the plant.

12. Three types of specialized structures that make use of large surface area to volume ratios are as follows:

- Your lungs have alveoli, which are small sacs that increase the surface area of the lungs so exchange of oxygen and carbon dioxide is more efficient.
- The villi and microvilli increase the surface area of the lining of the small intestine so more absorption can take place.
- Roots of plants have root hairs to increase the ability to absorb water and nutrients from the soil.

13. a. **Textbook questions 1, 2, 3, and 5 of "Check and Reflect," p. 293**

1. a. Surface area is the total area of the outer covering of an object.
   b. Volume is the total amount of space contained by an object.
   c. Surface area to volume ratio is the total surface area divided by the volume.

2. As a cell gets larger, its surface area to volume ratio decreases.

3. The efficiency of a cell's transport system limits the size of cells. A larger cell has to transport materials further within the cell and is less efficient.

5. The smaller the cell, the larger the surface area to volume ratio. A larger surface area to volume ratio results in a higher rate of diffusion across the cell membrane.

b. **Textbook questions 16 and 17 of "Section Review," p. 294**

16.

| Cell Number | Length (cm) | Width (cm) | Height (cm) | Surface Area $SA$ ($cm^2$) | Volume $V$ ($cm^3$) | Surface Area to Volume Ratio |
|---|---|---|---|---|---|---|
| 1 | 5 | 3 | 2 | 62 | 30 | 2.1 |
| 2 | 12 | 5 | 1 | 154 | 60 | 2.6 |
| 3 | 40 | 27 | 20 | 4840 | 21 600 | 0.22 |

17. Cell number 2 would have the fastest rate of diffusion across the surface since it has the highest surface area to volume ratio.

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# Conclusion

In this section you identified the various organelles of plant and animal cells and described how these organelles carry out the functions necessary for the cell to survive. You found that cells are capable of carrying on processes like the intake of nutrients, exchange of gases, waste removal, and reproduction.

Your body depends on the proper functioning of the cells that form the various tissues for your systems. These cells must be able to absorb nutrients and eliminate wastes efficiently. To lead an active lifestyle—like playing soccer or tennis, hiking in the mountains, or any other activity—you need your cells, organs, and organ systems to function at their maximum efficiency. It's amazing how something so small—like the functioning of a cell—can affect your lifestyle.

# Plants Are Multicellular Organisms with Specialized Structures

You can compare the individual players of a football team in the photograph to the specialized parts of a multicellular organism. Each player is responsible for performing a particular function to help the team win the game. Likewise, in a grape plant, each of the specialized parts—seeds, fruit, leaves, stem, bark, and roots—perform a particular function toward the goal of maintaining a viable living plant. In multicellular organisms, individual cells remain small, but the organism itself can be large when cells specialize to provide specific functions.

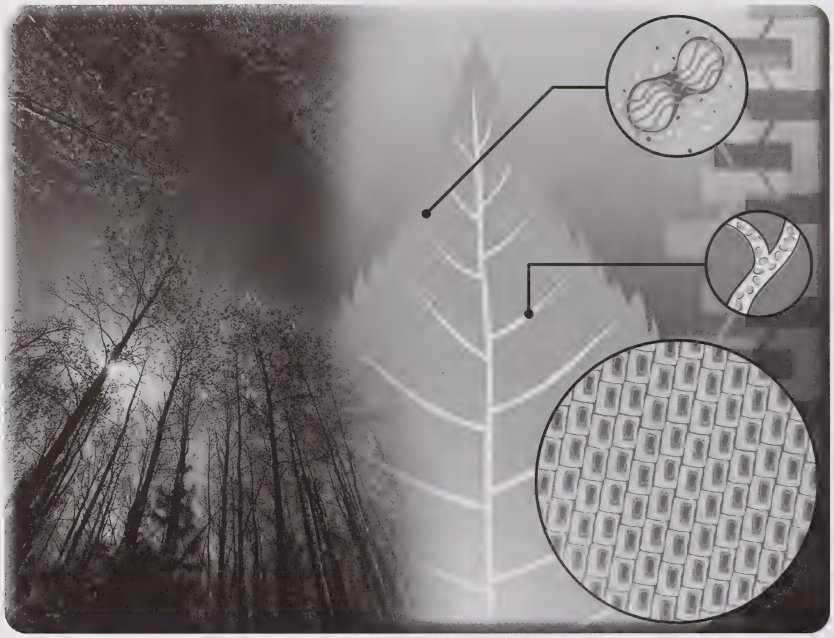
You have learned a little about cellular structure and function previously in this module. Some of the things you learned about cells can be applied to multicellular organisms.

In this section you will focus on plants as multicellular organisms with specialized structures at the cellular, tissue, and system levels. You will examine the mechanisms of transport, gas exchange, and environmental response in multicellular plants.

Turn to page 296 of the textbook and read the introduction to Unit C 3.0. Pay particular attention to the key concepts and learning outcomes listed. They provide a quick overview of the material you will study in this section.

# Lesson 1

## Cells, Tissues, and Systems



In multicellular organisms, cells specialize to carry out various functions. Many cells performing the same task make up tissues. A number of tissues grouped together to perform similar functions make up organs. Multicellular organisms depend on this specialization to carry out life processes.

Turn to page 297 of the textbook and read the introduction to "Cells, Tissues, and Systems" as well as the information in "Plant Structure" on pages 297 to 300.

1. What are the advantages and disadvantages of the multicellular organism?
2. How are cells that perform specialized functions similar?
3. Write the terms *system*, *tissue*, and *organ* in order of increasing complexity.
4. Name one tissue, one organ, and one system in the human body.
5. What does the shoot system of a plant consist of?
6. What does the root system of a plant consist of?

7. Is a tuber part of the shoot system or the root system?

8. What are meristems?

9. Name and describe the three main types of plant tissue.


Check your answers with those on pages 97 and 98.

**vascular tissue:** transport tissue formed of cells joined into tubes that carries water and nutrients throughout the plant

**Vascular tissue** is a general name for two types of parallel tube cells that are bundled together. The two types of tissue are **xylem tissue** and **phloem tissue**. You can see xylem and phloem tissues in Figure C3.7 on page 300 of the textbook.

**xylem tissue:** non-living tubes that move water and dissolved materials up the stem from the roots to the leaves

**phloem tissue:** sieve tube cells that transport sugars from the leaves to other parts of the plant

10. a. What is the purpose of xylem tissue and phloem tissue?
    b. Compare the structure of xylem tissue to the structure of phloem tissue.

11. What are companion cells?

12. What is a vascular bundle?


Check your answers with those on page 98.

After a period of time, plant cells that were part of the **meristem** become specialized for a particular function and produce only products needed for that function. Some specialized cells are root hairs, xylem and phloem cells, guard cells, and stomata.

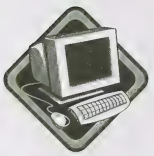
Read the information in "Specialization in Plant Cells" on pages 301 and 302 of the textbook.

**meristem:** an area where cell division occurs, resulting in the growth of the plant

13. State the purpose of each of the following parts of a plant.

    a. root hairs  b. dermal cells  c. guard cells  d. stomata


Check your answers with those on page 99.

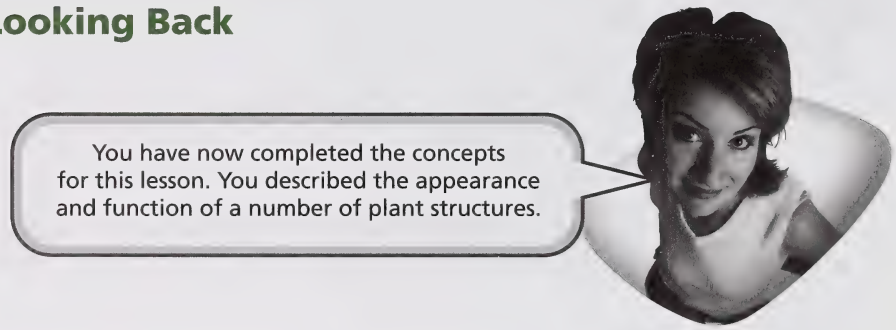


For more information on plant tissues, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Pages 297–300 and Text Pages 301–302. You will be provided with a list of informative links regarding plant tissues.

## Looking Back




14. Answer questions 2 and 5 of "Check and Reflect" on page 302 of the textbook.


Check your answers with those on page 99.


Go to pages 1 and 2 of Assignment Booklet 3C and answer questions 1 to 6.

## Glossary

**companion cell:** a cell connected to and that appears to direct the activities of sieve tube cells

**cuticle:** a waxy, waterproof coating on leaves and stems that prevents excess evaporation and helps the plant resist attack from micro-organisms

**epidermis:** the outer layer of cells that covers all plants

**ground tissue:** cells that make up the majority of the plant beneath the epidermis

**guard cell:** a cell on the lower epidermis of leaves that forms an opening for gas exchange

**meristem:** an area where cell division occurs, resulting in the growth of the plant

**organ:** tissues grouped together performing the same functions

**phloem tissue:** sieve tube cells that transport sugars from the leaves to other parts of the plant

**root system:** the part of the plant below the ground (one exception being aerial roots)

**shoot system:** the part of the plant above ground (one exception being tubers)

**stomata:** openings on the underside of leaves through which the exchange of gases occurs

**tissue:** a group of cells performing the same function together

**vascular bundle:** a grouping of phloem and xylem along with other associated tissues

**vascular tissue:** transport tissue formed of cells joined into tubes (phloem and xylem) that carries water and nutrients throughout the plant

**xylem tissue:** non-living tubes that move water and dissolved minerals up the stem from the roots to the leaves

## Suggested Answers

1. Advantages of the multicellular organism include the following:

    - Cells are specialized for one function and, thus, can perform it better.
    - Organisms can grow to a large size while maintaining the advantage of high surface area to volume ratio within the individual cells.
    - The life of a multicellular organism does not depend on a single cell. If one cell dies, others replace it.

    A disadvantage of the multicellular organism is that sometimes one type of cell can function abnormally and spread this abnormality to the entire organism. One example is cancer.

2. Cells that perform specialized functions are similar in that they contain the same genetic information.

3. The terms in order of increasing complexity are *tissue*, *organ*, and *system*.

4. Answers will vary. Examples of tissue include nerve tissue, muscle tissue, and connective tissue. Examples of organs include skin, heart, liver, lungs, stomach, and intestines. Examples of systems include the circulatory system, digestive system, and nervous system.

5. The shoot system consists of everything that is above the ground, such as the stem, leaves, buds, flowers, and fruit.

6. The root system consists of everything that is below ground, such as roots and root hairs. However, the root system can also include aerial roots, which appear above the ground.

7. A tuber is part of the shoot system even though it is below the ground.

8. Meristems are growth areas in plants where cell division occurs. The work of meristems over many years result in producing the large size of trees.

9. The three main types of plant tissue are

   - **dermal tissue:** the outer layer of cells that covers all non-woody plants and is responsible for the exchange of matter and gases

   - **cuticle:** the thin waxy coating on the leaves of plants that protects the plant from micro-organisms and reduces water loss due to evaporation

   - **ground tissue:** tissue—found beneath the epidermis and making up most of the plant—that provides strength and support for the plant, is the location for storage of food and water in roots, and is the site of photosynthesis in leaves

10. a. Xylem tissue moves water and dissolved minerals from the roots, up the stem, to the leaves. Phloem tissue transports sucrose and other sugars from the leaves to other parts of the plant.

    b. Xylem tissue is made up of thick-walled tubes of varying diameters. As the cells mature, they fuse together and break down at each end. The cytoplasm breaks down and the cells die, becoming a hardened mass of non-living tubes attached together.

    Phloem tissue is made up of long sieve tube cells that have no nuclei. These cells have perforated end walls so the cytoplasm can extend out. The tubes form continuous ducts along the length of the stem.

11. Companion cells are cells with nuclei attached to phloem cells and appear to direct the activities of the phloem cells.

12. A vascular bundle is a grouping of xylem and phloem cells.

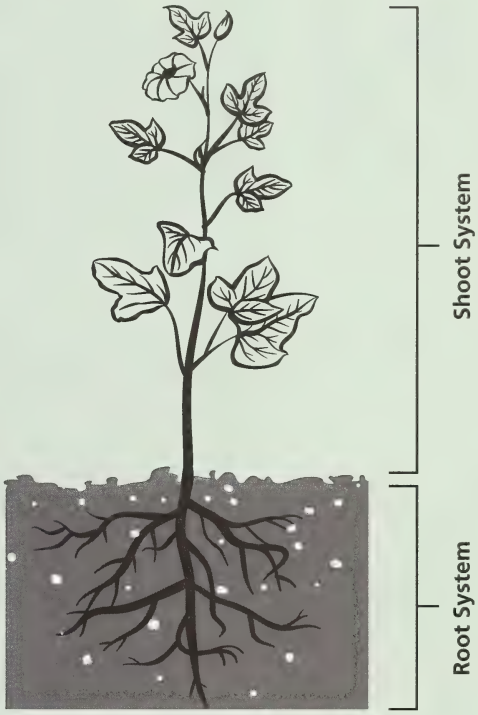
13. a. Root hairs increase the surface area available for roots to absorb water and minerals.
    b. Dermal cells produce cuticle.
    c. Guard cells form the tiny pores in leaves that allow for gas exchange.
    d. Stomata are the tiny pores in leaves formed by guard cells.

14. **Textbook questions 2 and 5 of "Check and Reflect," p. 302**

    2. There are two main organ systems in plants: the shoot system and the root system. The shoot system consists of all parts that are above ground, including leaves, the stem, flowers, seeds, and fruit. Some shoot systems do include modified stems, such as tubers that are underground (potatoes) and seeds that are underground (peanuts). The shoot system is responsible for the exchange of gases for photosynthesis and for the transport of water and nutrients to the various parts of itself.

       The root system consists of all parts that are underground, including roots and root hairs. In some cases, roots are above ground, called aerial roots. The root system is responsible for the absorption of water and minerals from the soil as well as the storing of products (root crops such as carrots and parsley).

       Your diagram should be similar to the one on the right.




    5. Plant leaves and stems are covered with cuticle to prevent excess evaporation of water and to protect against micro-organisms. Roots and root hairs are not covered with cuticle because water needs to be absorbed through the outer layer of cells.

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# Lesson 2

## The Leaf and Photosynthesis

**Photosynthesis:** the process through which plants convert light energy into chemical energy in the form of glucose

**Photosynthesis** occurs in the leaves of green plants and provides the basis of food for most living things on Earth. The grass in the photograph grows through photosynthesis and provides food for the cows. The cows, in turn, provide nourishment for humans as well as various other creatures in the food chain.

The basis of photosynthesis in plants is the chloroplast. Recall that chloroplasts are organelles containing the green pigment chlorophyll. It is the chlorophyll that captures light energy and converts it into chemical energy in the form of glucose.

Turn to pages 303 and 305 of the textbook and read the introduction to "The Leaf and Photosynthesis" and the information in "The Chloroplast: A Unique Plant Organelle."

1. a. How are chloroplasts easily identifiable?
   b. Where are chloroplasts found?

2. a. What does photosynthesis mean?
   b. Write the word and chemical equations for photosynthesis.

3. Are light and chlorophyll reactants or products in the photosynthesis process?

4. a. What is cytoplasmic streaming?
   b. What provided evidence of cytoplasmic streaming?
   c. What purpose does cytoplasmic streaming seem to serve in a cell?

Check your answers with those on pages 106 and 107

The following activity will provide you with an opportunity to determine how many chloroplasts are present in a typical plant cell.

## Inquiry Lab

# Counting Chloroplasts

Read the entire activity on page 304 of the textbook.

5. Predict how many chloroplasts, on average, are present in a typical cell of an *Elodea* leaf.


Check your answer with the one on page 107.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Follow the steps of the procedure as outlined on page 304 of the textbook. You will count chloroplasts in a number of typical plant cells and determine how many chloroplasts, on average, are present in a typical plant cell.

6. Copy and complete the following table.

| Cell Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Chloroplasts | | | | | | | | | | |

7. Answer the following on page 304 of the textbook.

   a. questions 1 and 2 of "Analyzing and Interpreting"
   b. question 3 of "Forming Conclusions"
   c. question 4 of "Applying and Connecting"


Check your answers with those on pages 107 and 108.

## Part B

The following data was obtained by a Science 10 student who viewed and counted chloroplasts using a microscope. Use the information in this table to answer question 7 in Part A.

| Cell Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Chloroplasts | 26 | 31 | 23 | 18 | 36 | 29 | 27 | 25 | 28 | 24 |

You may have heard that it is good to have plants where you live or work because plants produce oxygen. Plants use both carbon dioxide and oxygen. Plants use carbon dioxide for photosynthesis in which they produce glucose. Plants also use oxygen for cellular respiration, which provides the cell with its energy and produces carbon dioxide.

Turn to pages 305 and 308 of the textbook and read "Gas Production in Plants."

8. Write the word and chemical equations for cellular respiration.

9. How are the chemical equations for photosynthesis and cellular respiration related?

10. Why is the production of $CO_2$ from respiration not significant during the day?

11. Why is more carbon dioxide released at night?

12. How can you observe the production of a gas by plants?

Check your answers with those on page 108.

The next activity will show you how to determine if carbon dioxide is produced by plants.

# Inquiry Lab

## Evidence of Carbon Dioxide Production

Read the entire activity on pages 306 and 307 of the textbook.

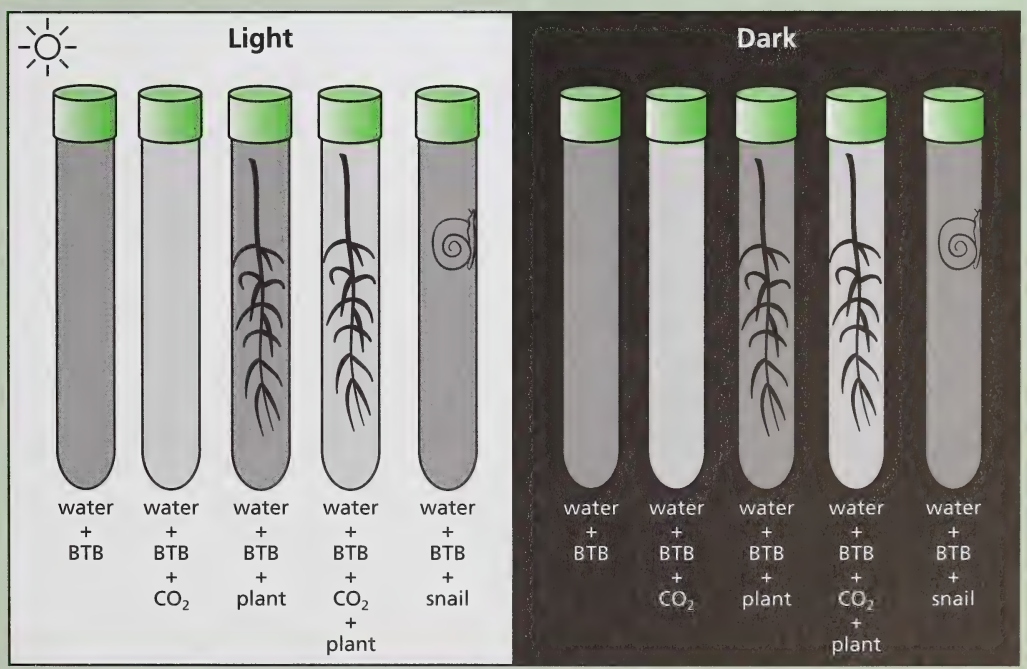
13. Predict as to whether the presence or absence of light will affect carbon dioxide production in an aquatic plant or animal.


Check your answer with the one on page 108.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

### Part A

Follow the steps of the procedure outlined on page 306 of the textbook. **Note:** BTB is the short form for bromothymol blue. **Pay special attention to the safety precautions mentioned**.



14. Copy and complete the following table. Record the colour of each solution after 24 hours.

| Vial Number | Vial Contents | Beginning Colour | Treatment | Ending Colour |
|---|---|---|---|---|
| 1 | water + BTB (control) | | light | |
| 2 | water + BTB (control) | | dark | |
| 3 | water + BTB + $CO_2$ (control) | | light | |
| 4 | water + BTB + $CO_2$ (control) | | dark | |
| 5 | water + BTB + plant | | light | |
| 6 | water + BTB + plant | | dark | |
| 7 | water + BTB + $CO_2$ + plant | | light | |
| 8 | water + BTB + $CO_2$ + plant | | dark | |
| 9 | water + BTB + snail | | light | |
| 10 | water + BTB + snail | | dark | |

15. Answer the following on page 307 of the textbook.

    a. questions 2, 3, and 4 of "Analyzing and Interpreting"
    b. questions 5 and 6 of "Forming Conclusions"
    c. question 7 of "Extending"

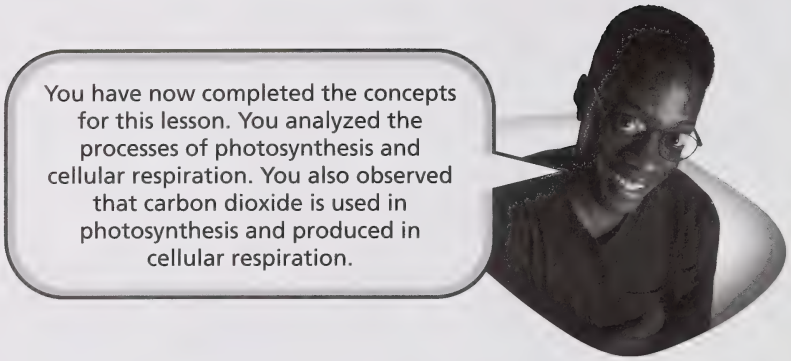

Check your answers with those on pages 108 to 110.

## Part B

Use the following table to answer question 15 in Part A.

| Vial Number | Vial Contents | Beginning Colour | Treatment | Ending Colour |
|---|---|---|---|---|
| 1 | water + BTB (control) | blue | light | blue |
| 2 | water + BTB (control) | blue | dark | blue |
| 3 | water + BTB + $CO_2$ (control) | yellow | light | yellow |
| 4 | water + BTB + $CO_2$ (control) | yellow | dark | yellow |
| 5 | water + BTB + plant | blue | light | blue |
| 6 | water + BTB + plant | blue | dark | green or yellow |
| 7 | water + BTB + $CO_2$ + plant | yellow | light | blue |
| 8 | water + BTB + $CO_2$ + plant | yellow | dark | yellow |
| 9 | water + BTB + snail | blue | light | green or yellow |
| 10 | water + BTB + snail | blue | dark | green or yellow |

## Looking Back




16. Answer questions 2, 3, 4, and 7 of "Check and Reflect" on page 308 of the textbook.

Check Check your answers with those on page 110.

Go to ... Go to pages 3 and 4 of Assignment Booklet 3C and answer questions 7 to 13.

## Glossary

**cellular respiration:** the breakdown of glucose to release chemical energy that a cell can use

**photosynthesis:** the process through which plants convert light energy into chemical energy in the form of glucose

## Suggested Answers

1. a. Chloroplasts are easily identifiable through their green colour.

   b. Chloroplasts are found in the ground tissue of leaves and sometimes the stems of plants. Some chloroplasts are found in the guard cells of leaves. (Refer to the top of page 302 of the textbook.)

2. a. Photosynthesis means "putting together with light."

   b. **word equation:** water + carbon dioxide $\xrightarrow{\text{chlorophyll and light}}$ glucose + oxygen

   **chemical equation:** $6\ H_2O(l) + 6\ CO_2(g) \xrightarrow{\text{chlorophyll and light}} C_6H_{12}O_6(aq) + 6\ O_2(g)$

3. Light and chlorophyll are neither reactants nor products in the equation for photosynthesis. They are required to make the reaction proceed.

4. a. Cytoplasmic streaming is the flow of the cytoplasm within a cell.
   b. The movement of chloroplasts provided evidence of cytoplasmic streaming.
   c. Cytoplasmic streaming appears to circulate materials and distribute them throughout the cell.

5. Answers will vary. You many have said 10, 15, or even 100.

6. Results will vary. Sample results are given.

| Cell Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of Chloroplasts | 26 | 31 | 23 | 18 | 36 | 29 | 27 | 25 | 28 | 24 |

7. a. **Textbook questions 1 and 2 of "Analyzing and Interpreting," p. 304**

   1. The mean (average) number of chloroplasts is 27 (rounded to the nearest whole number). A high count of chloroplasts was found near the leaf edge. The exposure to light is greater near the edge. **Note:** Average is the sum of the entries divided by the number of entries.

   2. You should have observed the chloroplasts moving in one direction around the edge of the cell. The function of cytoplasmic streaming is to distribute the contents of the cell throughout the cell. Chloroplasts in adjacent cells are moving in the same direction since cytoplasmic bridges connect the cells.

   b. **Textbook question 3 of "Forming Conclusions," p. 304**

   3. Your mean number of chloroplasts may or may not be close to the number of chloroplasts you predicted.

c. **Textbook question 4 of "Applying and Connecting," p. 304**

4. The three structures plants have that animals do not are chloroplasts, a cell wall, and a central vacuole.

   **chloroplasts:** Plants need chloroplasts to produce their own food. One reason might be that plants cannot move around; therefore, they need to produce their own food. Also, most plants do not have systems to use food from other organisms.

   **cell wall:** Plants do not have a skeleton for support; the cell wall provides a rigid structure.

   **central vacuole:** The central vacuole provides storage for water and helps the plant maintain rigidity due to increased turgor pressure.

8. **word equation:** glucose + oxygen → carbon dioxide + water + energy

   **chemical equation:** $C_6H_{12}O_6(aq) + 6\ O_2(g) \rightarrow 6\ CO_2(g) + 6\ H_2O(l) + \text{energy}$

9. The chemical equations for photosynthesis and cellular respiration are opposite. Photosynthesis uses water, carbon dioxide, and energy to produce glucose and oxygen. Cellular respiration uses glucose and oxygen to produce carbon dioxide, water, and energy.

10. The production of $CO_2$ from respiration is not significant during the day because plant tissues respire at a low rate and because plants are using carbon dioxide for photosynthesis.

11. At night, plants do not use carbon dioxide for photosynthesis, thus releasing it into the air.

12. You can observe the production of a gas by plants by observing the production of bubbles in water or by collecting the gas by displacing water.

13. Answers will vary. You may have said that the presence of light will affect carbon dioxide production in aquatic plants or aquatic animals.

14. Your completed table should be similar to the following.

| Vial Number | Vial Contents | Beginning Colour | Treatment | Ending Colour |
|---|---|---|---|---|
| 1 | water + BTB (control) | blue | light | blue |
| 2 | water + BTB (control) | blue | dark | blue |
| 3 | water + BTB + $CO_2$ (control) | yellow | light | yellow |

| | | | | |
|---|---|---|---|---|
| 4 | water + BTB + $CO_2$ (control) | yellow | dark | yellow |
| 5 | water + BTB + plant | blue | light | blue |
| 6 | water + BTB + plant | blue | dark | green or yellow |
| 7 | water + BTB + $CO_2$ + plant | yellow | light | blue |
| 8 | water + BTB + $CO_2$ + plant | yellow | dark | yellow |
| 9 | water + BTB + snail | blue | light | green or yellow |
| 10 | water + BTB + snail | blue | dark | green or yellow |

15. a. **Textbook questions 2, 3, and 4 of "Analyzing and Interpreting," p. 307**

2. Vials 1 and 2 show that the colour does not change in light or darkness with only water and bromothymol blue in the vial. Vials 3 and 4 also show that the colour does not change in light or darkness when there is water, BTB, and $CO_2$ in the vial.

3. Bromothymol blue changes from blue to yellow when carbon dioxide is added. The addition of carbon dioxide forms a weak carbonic acid solution, and bromothymol blue is yellow or green in an acid solution.

4. Bromothymol blue changed from blue to yellow after 24 hours in Vials 6, 9, and 10. Vial 6 contained a plant and was in the dark. Vial 9 contained a snail and was in the light. Vial 10 contained a snail and was in the dark. Bromothymol blue changed from yellow to blue in Vial 7, indicating that carbon dioxide was used up—the solution was no longer acidic. Vial 7 contained a plant and was in the light.

b. **Textbook questions 5 and 6 of "Forming Conclusions," p. 307**

5. From the results of the experiment, you can infer that plants produce carbon dioxide in the dark and animals produce carbon dioxide in both the light and the dark. Vial 7 shows that plants use carbon dioxide in the light. This is evident by the solution turning blue. Actually, plants produce carbon dioxide in both the light and the dark; however, they also use carbon dioxide in the light for photosynthesis, so no excess carbon dioxide is produced. Animals perform only cellular respiration and, therefore, produce carbon dioxide in both the light and the dark.

6. The presence of light does not have any affect on the production of carbon dioxide by animals. It does, however, appear to affect the production of carbon dioxide by plants. It is known that plants continue with cellular respiration in the presence of light, so carbon dioxide must be produced; but the carbon dioxide is not noticeable in the presence of light because it is used up by photosynthesis.

c. **Textbook question 7 of "Extending," p. 307**

7. You could remove the snails from Vials 9 and 10 after the 24-hour period and insert a plant into one of the vials. The other vial would be used as a control. Place the two vials in the light for 24 hours. The vial with the plant should turn blue, and the vial without a plant should remain yellow. You could repeat the experiment with another set of Vials 9 and 10 and put them in the dark for 24 hours. The solutions in both vials should remain yellow in colour. You could also leave the snails in and insert a plant into one of the vials. If the plant uses enough carbon dioxide the solution in the vial should turn blue.

16. **Textbook questions 2, 3, 4, and 7 of "Check and Reflect," p. 308**

2. The role of chlorophyll in photosynthesis is to absorb light energy and convert it into chemical energy.

3. In sunlight, plants carry out both photosynthesis and cellular respiration. In darkness, plants only carry out cellular respiration.

4. Knowing the size of a cell or an organelle helps to understand its function and its relationship to other organelles in the cell.

7. a. If more carbon dioxide were available, photosynthesis should be able to occur at a faster rate. This would depend on the amount of water available and may depend on the light intensity.

b. The rate of photosynthesis would increase if the light intensity was increased since more light energy is available.

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# Lesson 3

## The Leaf Tissues and Gas Exchange

The sites of gas exchange in plants are the stomata on the underside of the leaves. The stomata are openings formed by specialized cells called guard cells. These guard cells are able to open and close, thus controlling the amount of gas that can move through.

Some gases can enter by diffusion, but it is the stomata that control most of the gas exchange. The mechanism for opening and closing the stomata involves light and increasing and decreasing the concentration of potassium ions ($K^+$) in the guard cells.

Read the introduction to "The Leaf Tissues and Gas Exchange" and the information in "Dermal Tissue" on pages 309 and 311 of the textbook. You will discover how the mechanism for opening and closing the stomata works. Closely study the sequence of events in Figure C3.13 on page 309.

1. a. Describe what causes guard cells to absorb water from surrounding cells.
   b. What happens to guard cells when water enters?

2. Which gases important to the survival of plants pass through the stomata?

3. What causes stoma to close?

4. What is the process of water loss through leaves called?

5. How do guard cells protect the plant from losing too much water through its leaves?

6. How do plants adapt to environmental conditions with regard to number of stomata?

7. How do stomata react to changing carbon dioxide levels?

Check your answers with those on page 117.

The next activity analyzes the effects environmental factors have on the number and appearance of stomata and the ability of stomata to regulate transpiration.

## Inquiry Lab

# Analyzing Stomata

Read the entire activity on pages 310 and 311 of the textbook.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Follow the steps of the procedure as outlined on page 310 of the textbook.

8. Record your observations regarding the characteristics of the three plants in the following table.

**CHARACTERISTICS OF PLANTS**

| Cactus | Jade | Geranium |
|---|---|---|
| | | |

9. For each of the prepared slides you viewed, copy and complete a table like the following.

| Field of View | Diagram | Total Magnification | Number of Stomata |
|---|---|---|---|
| low power | | 40× | |
| medium power | | | |
| high power | | | |
| | | Average | |

10. Create a bar graph of the average number of stomata per unit area for each plant.

11. Answer the following on page 311 of the textbook.

    a. questions 1 to 4 of "Analyzing and Interpreting"
    b. questions 5 and 6 of "Forming Conclusions"


Check your answers with those on pages 118 to 121.

## Part B

Use the Internet or library materials to research the effects of environmental factors on the number and appearance of stomata and how transpiration is related to the number of stomata. In your search, enter phrases like *stomata under a microscope*, *stomata on a cactus plant*, *stomata on a geranium plant*, *stomata on pine needles*, and *stomata on Elodea* into any of the Internet's search engines. Use this information to answer the questions that follow.

12. How do the number of stomata compare in each of the four plants?

13. What is the relationship between the number of stomata and the environment in which a plant grows?

14. How do the stomata appear on pine needles?


Check your answers with those on page 121.

The upper epidermis and lower epidermis form the outside layers of a leaf. Between these two layers are two different types of cells that form the ground tissue of the leaf.

Read "Ground Tissue" and "Vascular Tissue" on pages 311 to 313 of the textbook. Study the diagram and the light micrograph of a leaf in Figure C3.15 on page 312 closely.

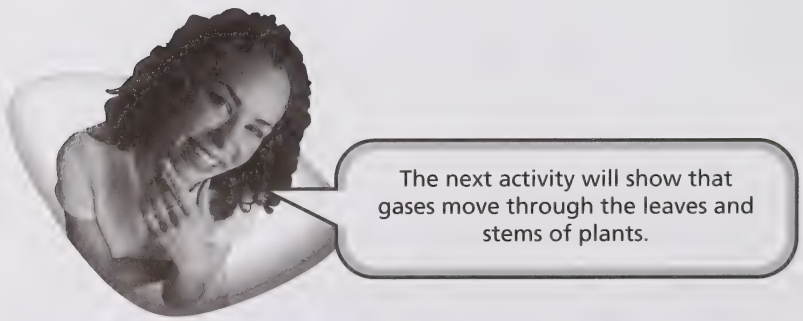
15. What are the names of the two types of cells in the region between the upper epidermis and the lower epidermis?

16. Why are palisade cells arranged in such a regular way?

17. How do the spaces between the cells in the spongy mesophyll layer help with diffusion of gases?

18. a. Where is the vascular tissue located in leaves?
    b. What is the purpose of vascular tissue in leaves?

Check Check your answers with those on page 121.



## Quicklab

### Airtight

Read the entire activity on page 312 of the textbook.

Obtain the required materials, and follow the steps of the procedure outlined. A small, clean juice bottle can be used.

19. Record your observations when air was withdrawn from the bottle.

20. Answer questions 1 and 2 of "Questions" on page 312 of the textbook.

Check your answers with those on pages 121 and 122.

All plants exchange gases by diffusion across the air spaces and across the cell membranes. Gas exchange takes place in leaves as well as on the stem.

Turn to page 313 of the textbook and read the information in "Gas Exchange in Plants."

21. How does diffusion occur on the stem of birch trees?

22. Which part of a plant is responsible for most of the gas exchange?

Check your answers with those on page 122.

## Looking Back

You have now covered all the concepts for this lesson. You analyzed gas exchange in plants and related the number of stomata to the moisture conditions where the plants grow.

23. Answer questions 1, 3, 6, 7, 8, and 12.a. of "Check and Reflect" on page 314 of the textbook.


Check your answers with those on page 122.


Lesson 5 contains an activity that requires materials that need to be obtained in advance as well as about one week to prepare the materials. Turn to pages 324 and 325 of the textbook and read "Inquiry Lab: Investigating Gravitropism and Phototropism" for a list of the materials you will need to obtain and set up in advance. The following information will help you prepare for this lab.

### Part 1

**step 1:** Obtain at least 4 corn seeds.

**step 2:** Pre-soak the seeds for 48 hours.

**step 3:** Place the seeds on a paper towel in a petri dish or CD case (as directed on page 324).

### Part 2

**step 1:** Obtain potting soil to fill a small planting tray (10 cm by 20 cm).

**step 2:** Obtain 20 to 30 oat seeds.

**step 3:** Plant the oat seeds, and water the seeds lightly every day until they germinate and grow to 2–3 cm above the soil.

**Use gloves and wash your hands after handling soil and seeds.**

Once you have set up the lab, answer the designated questions in Assignment Booklet 3C. Make sure you complete the Inquiry Lab in Lesson 5 as soon as your seeds have germinated and are ready to use.


Go to pages 4 and 5 of Assignment Booklet 3C and answer questions 14 to 19.

## Glossary

**lenticel:** an area of pores on the bark of some trees that allows gas exchange between the air and the inner part of the trunk

**mesophyll:** a general term for the two types of tissue found between the upper epidermis and the lower epidermis

**palisade tissue cell:** a cell where photosynthesis occurs and found just below the upper epidermis of leaves

**spongy mesophyll tissue:** a layer of loosely packed cells that allows for movement of gases within the leaf; found between the palisade cells and the lower epidermis

**transpiration:** the process of water leaving a leaf through the stomata

## Suggested Answers

1. a. Light stimulates guard cells to accumulate potassium ions ($K^+$) through active transport. Guard cells absorb water by osmosis from surrounding cells when the potassium ion ($K^+$) concentration in the guard cells is increased.

   b. The absorption of water causes guard cells to swell due to increased turgor pressure. The swelling causes the cells to separate and form an opening (stoma).

2. Water vapour, carbon dioxide, and oxygen pass through the stomata.

3. A stoma closes when potassium ions exit the guard cells, causing the water to exit as well. This reduces the turgor pressure, allowing guard cells to become limp and close the stoma.

4. The process of water loss through the leaves is called transpiration.

5. When water is not readily available, the guard cells stay closed and reduce the amount of water lost by the plant.

6. Plants that grow in hot, dry conditions have fewer stomata on the leaves than plants that grow in moist, humid conditions.

7. When carbon dioxide levels are low, stomata open to allow as much carbon dioxide to enter as possible.

8. Your table should be similar to the following.

**CHARACTERISTICS OF PLANTS**

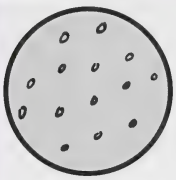
| Cactus | Jade | Geranium |
|---|---|---|
| • no leaves, just spines<br>• thick, waxy covering on entire plant<br>• little or no moisture on inside of bag | • small, waxy leaves<br>• leaves and stem have thick cuticle<br>• some moisture droplets inside bag | • large leaves<br>• leaves and stem have thin covering<br>• large amount of moisture inside bag |

9. Your completed tables should be similar to the following.

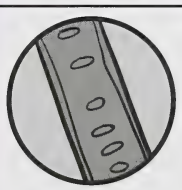
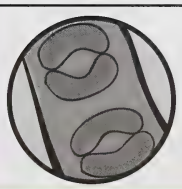
**CACTUS**

| Field of View | Diagram | Total Magnification | Number of Stomata |
|---|---|---|---|
| low power |  | 40× | 7 |
| medium power |  | 100× | 3 |
| high power |  | 400× | 1 |
| | | Average | 4 |

**GERANIUM**

| Field of View | Diagram | Total Magnification | Number of Stomata |
|---|---|---|---|
| low power |  | 40× | 26 |
| medium power |  | 100× | 14 |
| high power |  | 400× | 3 |
| | | Average | 14 |

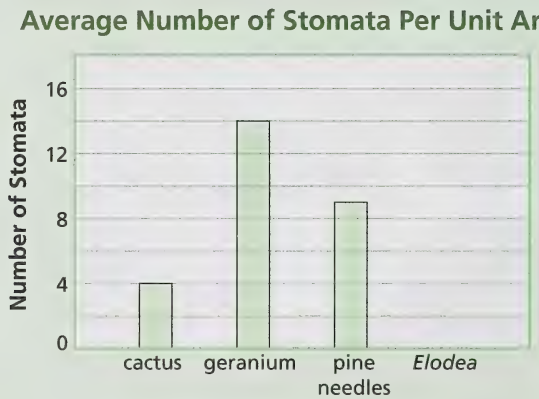
**PINE NEEDLES**

| Field of View | Diagram | Total Magnification | Number of Stomata |
|---|---|---|---|
| low power |  | 40× | 18 |
| medium power |  | 100× | 6 |
| high power |  | 400× | 2 |
| | | Average | 9 |

***ELODEA***

| Field of View | Diagram | Total Magnification | Number of Stomata |
|---|---|---|---|
| low power | | 40× | 0 |
| medium power | | 100× | 0 |
| high power | | 400× | 0 |
| | | Average | 0 |

10. Your graph should be similar to the following.




11. a. **Textbook questions 1 to 4 of "Analyzing and Interpreting," p. 311**

    1. The bag covering the cactus had very little or no moisture on the inside. The bag covering the geranium had the most moisture inside. The amount of moisture in the bag covering the jade plant was somewhere in between.

2. Less transpiration occurs with the cactus and jade plant. The most transpiration occurs with the geranium. The type of leaves (or lack of leaves) must have an effect on the transpiration rate of the plant. Both the cactus and the jade plant appear to have a waxy surface, which would prevent transpiration.

3. Most cells are polygonal but are often elongated or rectangular. The size of cells varies among different plants species.

4. Chloroplasts were found in the guard cells within the epidermis.

b. **Textbook questions 5 and 6 of "Forming Conclusions," p. 311**

5. Plants that grow in low-moisture conditions have less stomata per unit area than those that grow in high-moisture conditions. Plants that grow in water (e.g., *Elodea*) have no stomata at all.

6. The more stomata per unit area, the greater the amount of transpiration. The geranium in this activity proved this.

12. The cactus has the least number of stomata, and the geranium has the most. The *Elodea* is a water plant that has no stomata.

13. A plant that grows in low-moisture conditions has fewer stomata per unit area, whereas a plant that grows on land in high-moisture conditions has many stomata per unit area.

14. Stomata on pine needles are in rows along the length of the needle.

15. Palisade tissue cells and spongy mesophyll tissue cells are the two types of cells between the upper epidermis and the lower epidermis.

16. Palisade tissue cells are arranged in such a regular way because they are responsible for photosynthesis. The regular arrangement of these cells under the upper epidermis gives them maximum exposure to the Sun.

17. The spaces between the cells allow for the movement of gases through the leaf and stem. This helps the movement of carbon dioxide to and oxygen from the palisade tissue cells.

18. a. The vascular tissue in leaves is located in the ribs (leaf veins) you can see running through a leaf.

b. The purpose of vascular tissue in leaves is to bring water and dissolved salts into the leaf and transport sugars to the rest of the plant.

19. You should have observed bubbles coming from the bottom of the stem as air was withdrawn from the bottle.

20. **Textbook questions 1 and 2 of "Questions," p. 312**

    1. Bubbles were coming from the bottom on the stem as air was withdrawn from the bottle.

    2. Air enters the leaf and stem through the stomata and then moves down the stem and into the water to replace the air that was removed from the space above the water.

21. Diffusion occurs through lenticels on the surface of the bark. The lenticels allow for gases, including water, to pass through.

22. Most of the exchange of gases occurs through the leaves of a plant.

23. **Textbook questions 1, 3, 6, 7, 8, and 12.a. of "Check and Reflect," p. 314**

    1. Your drawing should be similar to Figure C3.15 on page 312 of the textbook.

    3. The function of stomata is to allow for the movement of gases into and out of the leaf as well as to regulate the amount of water that passes out of a leaf.

    6. Environmental stresses that would cause stomata to close include drought conditions, winds, and excessive heat. These conditions cause excess evaporation, so the stomata would close to minimize water loss.

    7. Having palisade tissue directly below the epidermis allows for maximum exposure of the palisade tissue cells to the Sun. This in turn allows for maximum photosynthesis to occur.

    8. Having stomata on the underside of the leaf reduces their exposure to direct sunlight, which will reduce evaporation as well as stress on guard cells.

    12. a. Needles have less stomata than leaves, so trees that have needles are better adapted for drier climates, such as those at high altitudes. Also, the structure and outer covering of the needles is such that water loss is minimal.

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# Lesson 4

## Transport in Plants

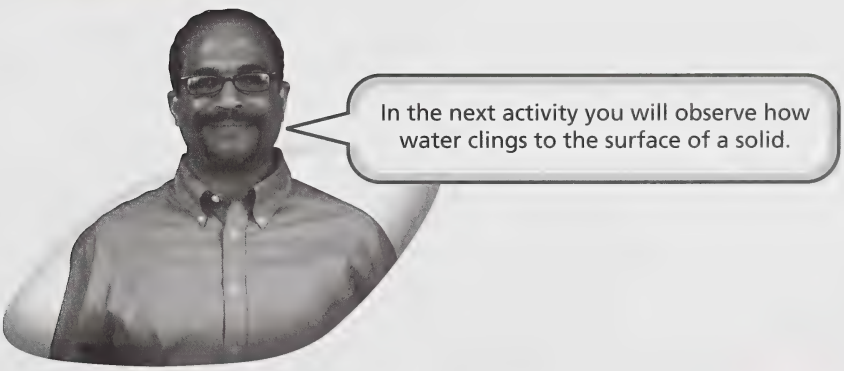
Have you visited or at least heard about the giant California redwoods? These amazing trees can grow up to 100 m tall! In Alberta, even the trees in the central and north central regions of the province consist of tall aspens that can reach heights of up to 25 m.

How do trees like the California redwoods and the aspens of Alberta get water and minerals from their roots to their leaves way up at the top?

Turn to page 315 of the textbook and read the introductory paragraphs of "Transport in Plants."

1. Name three plant structures involved in the movement of water and other materials in plants.

Check Check your answer with the one on page 131.



## Quicklab

# Capillary Action

Read the entire activity on page 315 of the textbook.

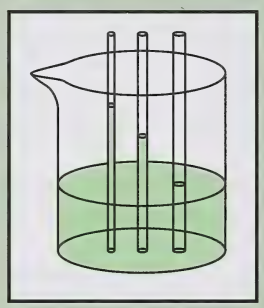
If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

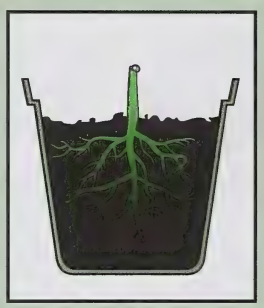
Follow the steps outlined in the procedure on page 315 of the textbook.

**Step 1**

**Step 2**



**Step 3**



2. Answer questions 1 to 5 of "Questions."


Check your answers with those on pages 131 and 132.

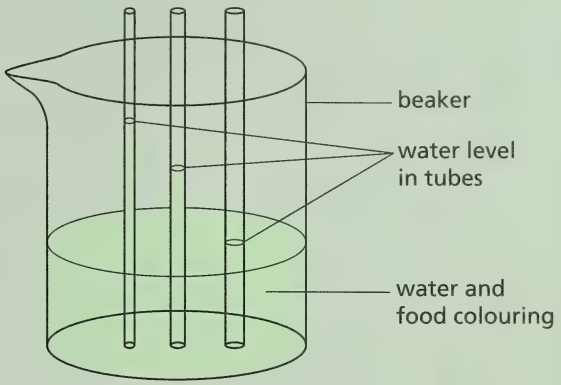
## Part B

Complete steps 1 and 3 of the procedure on page 315 of the textbook. For step 1, you can use your finger to add one drop of water at a time to a penny. For step 3, if you are cutting a stem from a house plant, cut only a small stem with a single leaf. Be sure to check if it is okay for you to cut a part of the plant if the plant is not yours.

**Pay careful attention when cutting stems.**

The following diagram shows the observations made by a student who performed step 2 of the procedure.

**Step 2: Capillary Tubes**




Use the preceding information and your results in steps 1 and 3 to answer question 2 in Part A.

In the preceding activity you saw that water droplets cling to themselves and to the surface of a penny. Scientists have different names for the attraction of liquid molecules to each other and to other surfaces.


For more information, turn to page 316 of the textbook and read "Cohesion and Adhesion."

3. What is cohesion?

4. What is adhesion?

5. Do you think plants would be able to draw soapy water up the stem? Explain.


Check your answers with those on page 132.

Other ways through which water moves up the stem to the leaves in plants are **root pressure** and **transpiration pull**. Roots draw water and minerals from the soil. This creates a greater pressure in the roots than there is in the stem and leaves, thus forcing the water up the stem. Transpiration pull results from the evaporation of water through the leaves. This creates a pull on the water within the stem and leaves.

Turn to pages 316 to 318 of the textbook and read "Root Pressure" and "From Root to Leaf: Water Transport in Plants."

**root pressure:** pressure exerted on water in the roots by osmosis

**transpiration pull:** a pull on water molecules in xylem due to the evaporation of water through stomata and lenticels

6. What evidence is there that root pressure occurs?

7. Through what process is water drawn into the roots?

8. How does transpiration pull work to move water up the stem of a plant?

9. How does temperature affect transpiration pull?

10. Closely study Figure C3.19 on page 317 of the textbook. Then answer questions 1 to 4 of "Minds On . . . Colourful Carnations."

11. Carefully study Figure C3.20 on page 318 of the textbook. Name the processes involved at each of the following locations that help to move water from the ground up through the stem to the leaves and out into the air.

    a. root system  b. stem  c. leaves


Check your answers with those on page 132.

In the next activity you will observe the effect of concentration of solute particles on plant cells. The concentration of solute particles in solutions separated by a semi-permeable membrane is referred to as **tonicity**.

**tonicity:** a term that relates the concentration of solute particles in solutions separated by a semi-permeable membrane

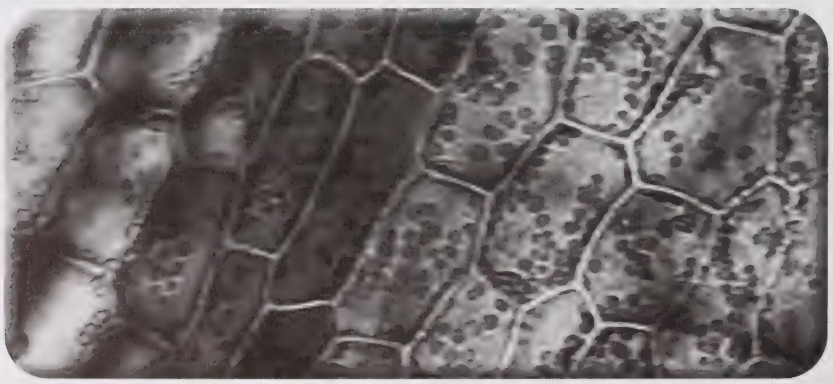


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**Figure 2.4:** *Elodea* leaf cells

## Inquiry Lab

# Tonicity and Plant Cells

Read the entire activity on page 319 of the textbook.

12. Predict the effect of increased tonicity of the environment on plant cells.


Check your answer with the one on page 133.

If you have access to a supervised laboratory, do **Part A**. If you do not have access to a supervised laboratory, do **Part B**.

## Part A

Follow steps 1 to 6 of the procedure outlined on page 319 of the textbook. **Pay special attention to the safety precautions mentioned.**

13. Do the following as you complete the procedure.

    a. Draw a diagram of the field of view of *Elodea* leaf cells, and calculate the size of *Elodea* leaf cells (step 3).

    b. Describe the movement of material around the cell and into and out of the cell (step 4).

    c. Describe the changes in the cell structures after adding the salt solution (step 6).

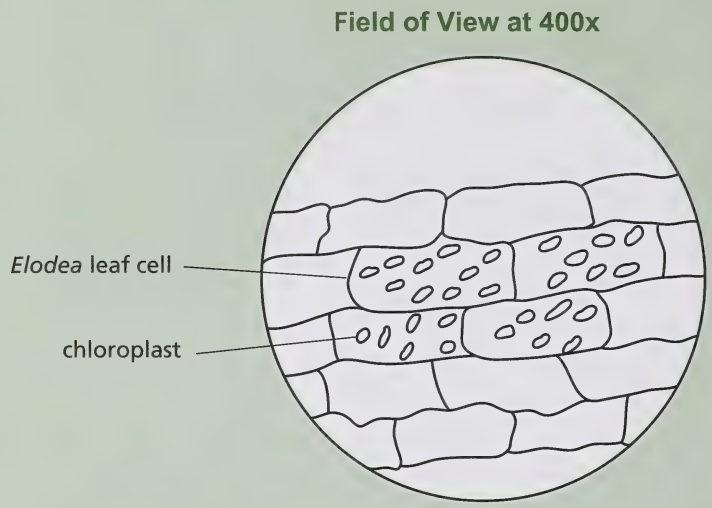
14. Answer the following on page 319 of the textbook.

    a. questions 1 to 4 of "Analyzing and Interpreting"
    b. question 5 of "Forming Conclusions"


Check your answers with those on pages 133 and 134.

## Part B

The following is a diagram of *Elodea* leaf cells drawn by a student who observed them using a microscope with a total magnification of 400×.




15. Use the diagram of *Elodea* leaf cells under 400× to calculate the actual size of an *Elodea* leaf cell in micrometres (μm). Assume the field diameter of a microscope with a total magnification of 40× to be 4.5 mm.

Check your answer with the one on page 134.

Insert the Science 10 Multimedia CD into your computer, and view the segment "Cytoplasmic Streaming in *Elodea* Cells." In this segment you will get a close-up view of the cytoplasmic streaming in an *Elodea* leaf cell.

16. What observations can you make about cytoplasmic streaming in *Elodea* leaf cells?

Check your answer with the one on page 134.

Cut a leaf from a healthy plant. Observe the shape of the leaf and how it holds its shape. Immerse the leaf for about two minutes in a salt solution made with about 5 mL of table salt in 100 mL of water. Remove the leaf and lay it down on a paper towel to absorb excess moisture.

17. a. Pick up the leaf and observe its shape and how it holds its shape. Record your observations.

    b. What do you think happened to the leaf to cause the change?

18. What term is used to describe the salt solution relative to the leaf's cell contents?


Check your answers with those on page 134.

Turn to page 320 of the textbook and read "The Effect of Tonicity on Plant Cells." Study the photographs in Figure C3.21 closely.

19. a. Describe plasmolysis.
    b. What is the effect of plasmolysis on a leaf of a plant?

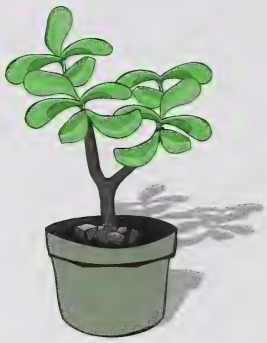
20. What happens to a plant that has been in a salt solution for a few minutes when it is returned to fresh water?

21. Why is turgidity important to green plants?


Check your answers with those on page 134.

In addition to water, plants need a supply of food (sugars) to survive. Xylem and phloem cells are the mechanism for transport of sugars throughout the plant.

Read "From Source to Sink: Sugar Transport in Plants" on pages 320 and 321 of the textbook. Study Figure C3.22 on page 321 carefully.



22. Why are xylem and phloem cells important to the survival of the plant?

23. What terms are used for where sugars are manufactured and where they are used or stored?

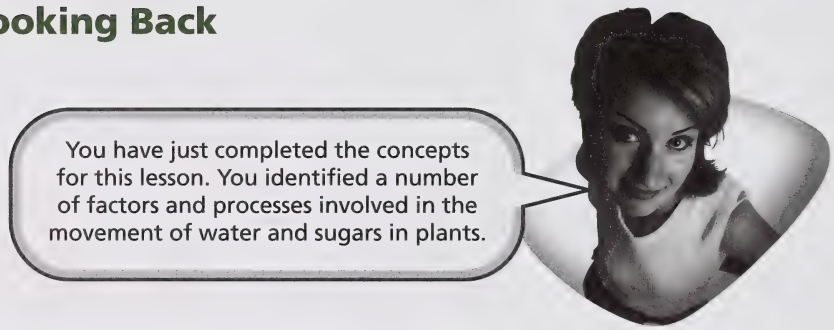
24. Describe the mechanism by which the sugars are moved from the leaves to the rest of the plant.

25. What are the sugars used for when they are passed on to the rest of the plant?

26. How is the constant flow of sugar and water down the phloem maintained?

Check Check your answers with those on pages 134 and 135.

## Looking Back




27. Answer questions 1, 2, 3, and 9 of "Check and Reflect" on page 322 of the textbook.

Check Check your answers with those on page 135.

Go to ... Go to pages 5 to 7 of Assignment Booklet 3C and complete questions 20 to 28.

## Glossary

**adhesion:** the tendency of unlike molecules to stick together

**capillary action:** the movement of a liquid along the surface of a solid

**cohesion:** the tendency of like molecules to stick together

**plasmolysis:** the shrinking of the cytoplasm and the cell membrane away from the cell wall due to the outflow of water from the cell

**pressure-flow theory:** an explanation of how plant nutrients are transported from leaves to other parts of the plant, driven by pressure built up by hypertonic solutions in the phloem

**root pressure:** pressure exerted on water in the roots by osmosis

**sink:** a place in a plant where products of photosynthesis are stored

**source:** a place in a plant where products of photosynthesis are manufactured

**tonicity:** a term that relates the concentration of solute particles in solutions separated by a semi-permeable membrane

**transpiration pull:** a pull on water molecules in xylem due to the evaporation of water through stomata and lenticels

## Suggested Answers

1. Cell membranes, vacuoles, and vascular tissues are involved in the movement of water and other materials in plants.

2. **Textbook questions 1 to 5 of "Questions," p. 315**

    1. Answers will vary. If you were able to use a dropper, you may have been able to get about 40 drops to stay on the penny. If you used your finger as a dropper, you may have been able to get 60–70 drops to stay on the penny since the drops off the finger are smaller. Was it more drops than you expected? Did you notice that the water makes a high spot in the centre?

    2. When the liquid dish detergent was added, the water ran off. Yes, one or two more drops could have probably been added.

    3. The coloured water moved up the most in the capillary tube with the smallest diameter.

    4. The narrower the capillary tube, the further the coloured water travels up the tube.

5. After the stem was cut, the roots continue to absorb water and cause water to move up the stem. The water did not drain back down into the roots because the water molecules were clinging to one another and to the sides of the vascular tissues in the stem.

3. Cohesion is the tendency of molecules of the same kind to stick together.

4. Adhesion is the tendency of unlike molecules to stick together.

5. No, plants would not be able to draw soapy water up the stem because the adhesion of soapy water to the sides of the vascular tubes would not be as great as with plain water.

6. In the early morning, you can see droplets of water on the tips of leaves. This is evidence that water is being forced through the plant even though the rate of transpiration is low.

7. Water is drawn into the roots through osmosis.

8. When water evaporates from the leaves, a pull on the water inside the leaves and stem is created.

9. The higher the temperature, the more evaporation and, therefore, the stronger the transpiration pull. This moves water more quickly through the stem.

10. **Textbook questions 1 to 4 of a "Minds On . . . Colourful Carnations," p. 317**

    1. In the carnation, the coloured water moved up the stem and into the flower. Each colour moves only into its half of the carnation. In the celery stalk, the colour moved up mostly in tubes around the outer edge.

    2. You can infer that water moves up the stem through the tubes only. It does not spread throughout the plant.

    3. The cells that are stained are the vascular tissue cells. Other cells appear to be slightly coloured, but this could be due to osmosis through the cell membranes.

    4. The vascular bundles work like capillary tubes. The water adheres to the sides of the vascular tissue and water molecules cling to each other by cohesion. This adhesion and cohesion slowly moves the water up the stems.

11. a. In the root system, water is moved from the soil into the roots by osmosis. It is then moved toward the stem by root pressure.

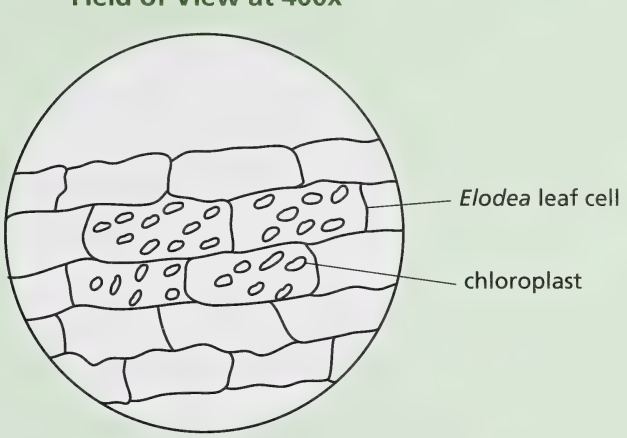
    b. In the stem, water is moved by root pressure and transpiration with the help of the forces of adhesion and cohesion.

    c. In the leaves, water is moved through transpiration pull and by diffusion through the air spaces.

12. Predictions may vary. A sample prediction is given.

    An environment of increased tonicity will cause water to move out of the cell.

13. a. Diagrams should be similar to the following.




Diameter of field of view at $40\times = 4.5$ mm

$$\text{Diameter of field of view at } 400\times = \frac{40\times}{400\times} \times 4.5 \text{ mm}$$
$$= 0.45 \text{ mm}$$

$$\text{Estimated size of } \textit{Elodea} \text{ leaf cell} = \frac{1}{3} \text{ of field of view}$$

$$\text{Actual size of } \textit{Elodea} \text{ leaf cell} = \frac{1}{3} \times 0.45 \text{ mm}$$
$$= 0.15 \text{ mm}$$
$$= 150 \text{ µm}$$

The actual size of the *Elodea* leaf cell is 150 µm.

b. You should be able to see the movement of chloroplasts, particularly around the edges of the cell.

c. The vacuole shrinks in size and movement within the cell slows down as water moves out of the cell.

14. a. **Textbook questions 1 to 4 of "Analyzing and Interpreting," p. 319**

    1. You should see the movement of chloroplasts, especially around the edges of the cell.

2. Over time, the central vacuole shrinks in size and there is more room for chloroplasts. Movement slows down as water moves out of the cell due to evaporation from the heat of the microscope light. The variable responsible for the relationship is time.

3. Adding the salt solution made the surrounding environment hypertonic to the cell contents.

4. The hypertonic environment causes the water to move out of the cell. The water in the vacuole moves out and the vacuole shrinks in size. As the entire cell loses its turgidity (firmness of cell wall), you may observe the cell wall shrivel.

b. **Textbook question 5 of "Forming Conclusions," p. 319**

5. The vacuole shrinks in size, and the entire cell wall loses its turgidity. The mechanism responsible is the movement of water across the cell membrane and out of the cell by osmosis.

15. Refer to the answer to question 13.a.

16. The chloroplasts move around the cell, particularly along the edge of the cell wall.

17. a. The leaf was quite firm and kept its shape when it was cut from the plant. After immersing it in the salt solution, the leaf became limp and curled.

b. The salt solution caused the water in the cells to move out into the salt solution, reducing the turgidity of the cells in the leaf.

18. The salt solution is hypertonic to the leaf's cell contents.

19. a. Plasmolysis is the shrinking of cells when the environment outside the cell has a higher solute concentration than inside the cell.

b. Plasmolysis causes the leaf of a plant to become wilted or limp.

20. Water re-enters the plant, and the plant regains its turgidity.

21. Turgidity is important in green plants because it holds the green parts of the plants up to the sunlight.

22. The xylem and phloem are part of the transport system. The xylem brings water up to the leaves from the roots, and the phloem brings sugar and water down from the leaves to the remainder of the plant.

23. The leaves where the sugars are manufactured are called the source. The rest of the plant where the sugars are used or stored is called the sink.

24. The sugars move into the phloem through active transport, and water moves into the phloem by osmosis. This increases the pressure in the phloem and pushes the water and sugar through the phloem and into the rest of the plant.

25. The sugars are used for growth and respiration or may be stored in roots, stems, fruit, and leaves.

26. The constant flow of sugar and water in the phloem is maintained through pressure differences produced by active transport and osmosis. As sugar and water move down the phloem and into the cells, a reduced pressure is created in the sink. This forces more sugar and water to move into the phloem from the source.

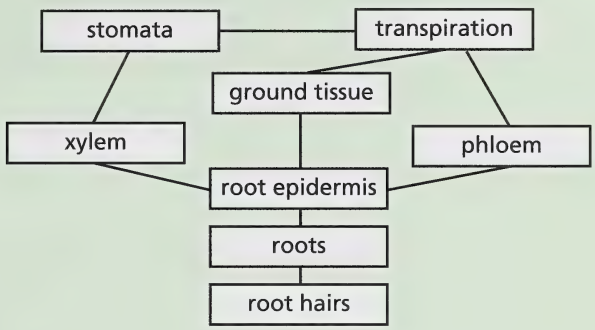
27. **Textbook questions 1, 2, 3, and 9 of "Check and Reflect," p. 322**

    1. The properties of water that aid in water transport in plants are adhesion and cohesion.

    2. In a hypertonic solution, water inside the cell and inside the vacuole will move through the cell membrane to the outside of the cell. This will cause the vacuole to shrink. In a hypotonic solution, water from outside the cell will move through the cell membrane to the inside of the cell and into the vacuole. This will cause the vacuole to swell.

    3. Plants use the stomata to control water loss. When evaporation rates are high, the stomata will close to reduce water loss. In the long term, plants that have adapted to dry conditions have few stomata and have a waxy covering on the leaves (if they have leaves) and stem.

    9. Answers will vary. A sample concept map is given.

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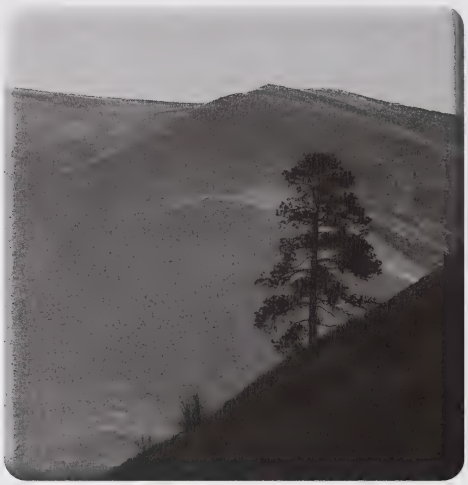
# Lesson 5

## Control Systems

Why do trees on a hillside grow straight up? Why do roots grow down and stems grow up? Why do plants potted near a window lean toward the window as it grows?



**stimulus:** something in the environment that causes a reaction by an organism

Plants respond to **stimuli** in their environment. The pull of gravity, Earth's magnetic field, and the location of a light source are examples of stimuli that plants respond to.

For more about some of the terms used with plant responses to stimuli, read the introduction to "Control Systems" on page 323 of the textbook.

1. Give two examples of stimuli that you might react to.

2. a. What is phototropism?
   b. Describe positive phototropism and negative phototropism.

3. Describe positive gravitropism and negative gravitropism.

4. Why do plants respond to light and gravity in the way that they do?

Check your answers with those on page 142.

## Did You Know?

House plants placed near a window will lean toward the window in response to the light stimulus. People who keep house plants often turn them so a new side is facing the window every few weeks. This helps keep the plant growing straight up, and it gives the leaves away from the window the stimulus to grow when turned toward the window.

The following activity investigates gravitropism and phototropism. In Part 1 of the activity you will conduct an experiment to determine whether gravity is responsible for the direction of growth of the stems and roots. In Part 2 you will conduct an experiment to determine which part of the stem is responsible for phototropism.

## *Inquiry Lab*

### Investigating Gravitropism and Phototropism

Read the entire activity on pages 324 and 325 of the textbook.

You will need to use the corn seeds and oat seeds you prepared earlier for this activity. To refresh, the corn seeds (for Part 1) need to be pre-soaked for 48 hours and the oat seeds (for Part 2) need to be planted, germinated, and growing for several days to a week.

**Use gloves, and wash your hands after handling soil and seeds.**

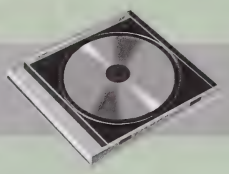
5. Make a hypothesis for Parts 1 and 2 of this lab.

Check your answer with the one on page 142.

## Part 1

Obtain all the required materials, and follow steps 1 to 8 of the procedure in Part 1 on page 324 of the textbook. Choose a location that is as dark as possible. Many cupboard doors and closet doors have spaces that will allow some light.

**Note:** If you do not have access to petri dishes, CD cases will work just fine.



6. Record your observations of how the stem and root of each corn seed grew.

7. Answer the following on page 325 of the textbook.

   a. question 1 of "Part 1: Analyzing and Interpreting"
   b. question 2 of "Part 1: Forming Conclusions"

Check Check your answers with those on pages 142 and 143.

## Part 2

Follow steps 4 to 9 of the procedure in Part 2 on page 325 of the textbook. Setting the tray in a window location will ensure that light is reaching the tray from one side.

8. Answer the following on page 325 of the textbook.

   a. questions 1 and 2 of "Part 2: Analyzing and Interpreting"
   b. question 3 of "Part 2: Forming Conclusions"
   c. question 4 of "Part 2: Extending"

Check Check your answers with those on pages 143 and 144.

In the previous activity you observed the effects of phototropism and gravitropism. Now, you will learn how phototropism and gravitropism work.

Read "Investigations of Phototropism" and "The Mechanism of Gravitropism" on pages 326 and 327 of the textbook. Study Figures C3.25 and C3.26 closely.

9. a. Which scientists studied phototropism and what questions did they ask?

   b. Describe how each of the scientists investigated their question and what they concluded from their investigations.

10. What name has been given to and what class of substance is the chemical responsible for the stimulus for phototropism?


Check your answers with those on pages 144 and 145.

To research other hormones that influence plant growth, visit the following website:

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links." Scroll down to Text Pages 323–327 to find a list of informative websites to conduct your research. One hormone you might wish to research is ethylene, which is used to ripen fruit. It also stimulates plants in a number of other ways.

11. Describe what scientists believe is the mechanism of gravitropism and how it works.


Check your answer with the one on page 145.

In addition to phototropism and gravitropism, scientists have identified other control mechanisms in plants. You may already be familiar with some of these systems. One example is the tendrils of a pea plant that allows the pea plant to wrap itself around a nearby wire fence or stake for support as the plant grows.

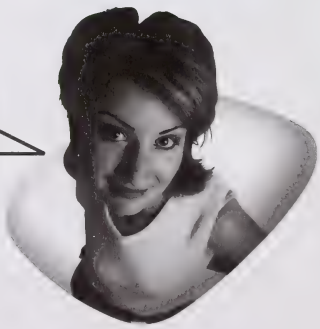
Turn to page 328 of the textbook and read the information in "Other Control Mechanisms."

12. What are four response mechanisms other than phototropism and gravitropism that plants respond to?

13. How do flowering plants respond to the length of darkness?

Check your answers with those on page 145.

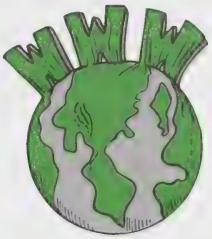
If you know someone who enjoys plants, ask them if they put particular plants in a room with low light conditions to try to make the plants flower at a particular time of the year.



Phototropism and gravitropism are often studied in space. Visit the following website to research the study of phototropism and gravitropism in space.

**http://www.scienceman.com/science10**

Once there, click on "Unit C: Hot Links" and scroll down to Text Page 323–327. Refer to readings, research, or resources next to "Plants in Space." You will find information on various experiments that have been done with plants in space.

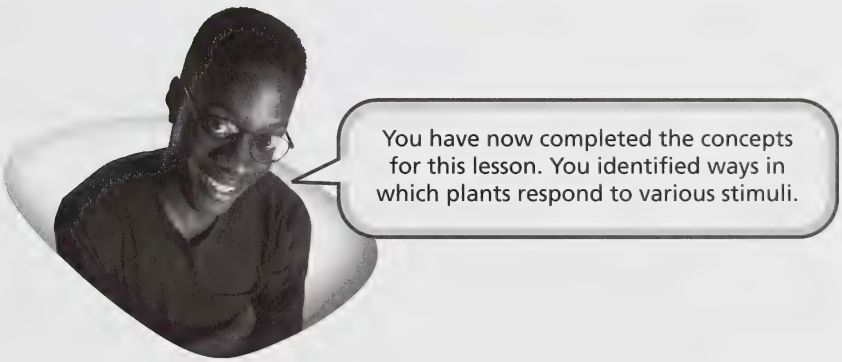


Now, turn to page 329 of the textbook and read "Career and Profile." You will read about the career of Dr. Olga Kovalchuk, a biotechnology research scientist.

14. Answer questions 1, 2, and 3 of "Career and Profile" on page 329 of the textbook.

Check Check your answers with those on page 145.

## Looking Back




15. Answer questions 1, 2, 3, 6, and 8 of "Check and Reflect" on page 328 of the textbook.

Check Check your answers with those on page 146.

Go to ... Go to pages 7 to 9 of Assignment Booklet 3C and answer questions 29 to 35.

## Glossary

**auxin:** a plant hormone that promotes cell elongation in stem cells as a response to a light source

**control system:** a system within plants that produces definite responses to specific stimuli

**gravitropism:** the growth response of plants to Earth's gravitational system

**hormone:** a chemical produced by a cell in one location that travels to another location where it produces an effect

**phototropism:** the growth response of plants to light conditions

**stimulus:** something in the environment that causes a reaction by an organism

## Suggested Answers

1. Heat, cold, loud noises, and smell are examples of stimuli you might react to.

2. a. Phototropism refers to the growth movement of a plant in response to light.

   b. Positive phototropism is the response of the stem of a plant to grow toward a source of light. Negative phototropism is the response of a root of a plant to grow away from a source of light.

3. Positive gravitotropism is the response of the root of a plant to grow toward the force of gravity. Negative gravitropism is the response of a stem of a plant to grow against the force of gravity.

4. Plants respond to light and gravity the way that they do to meet their needs. Roots respond positively to gravity and negatively to light in order to maintain their growth in the soil, where they absorb water and minerals. Stems respond negatively to gravity and positively to light in order to grow toward a source of light so photosynthesis can proceed. The responses to both of these tropisms ensure the survival of the plant.

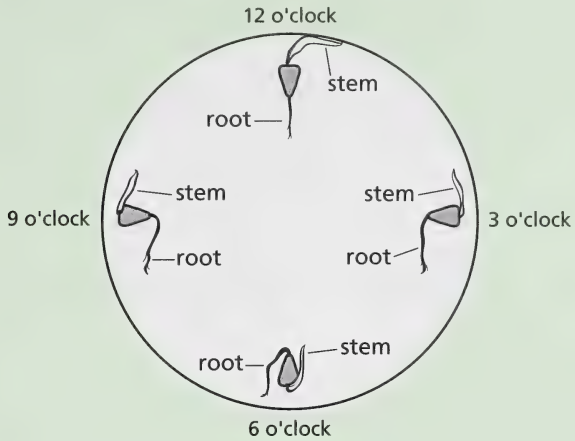
5. **Part 1 Hypothesis:** The arrangement of the seeds will show a difference in the direction that the stem and root grow.

   **Part 2 Hypothesis:** The different conditions should show that no bending occurs when the tip is covered and that bending still occurs when only the tip is exposed.

6. The seed at the 12 o'clock position grew stem up and root straight down. The seed at the 3 o'clock position grew stem up and root down. For the seed at the 6 o'clock position, the stem grew around the seed and up and the root grew around the seed and down. For the seed at the 9 o'clock position, the stem grew up and the root grew down.

7. a. **Textbook question 1 of "Part 1: Analyzing and Interpreting," p. 325**

1. Your diagram should be similar to the following.

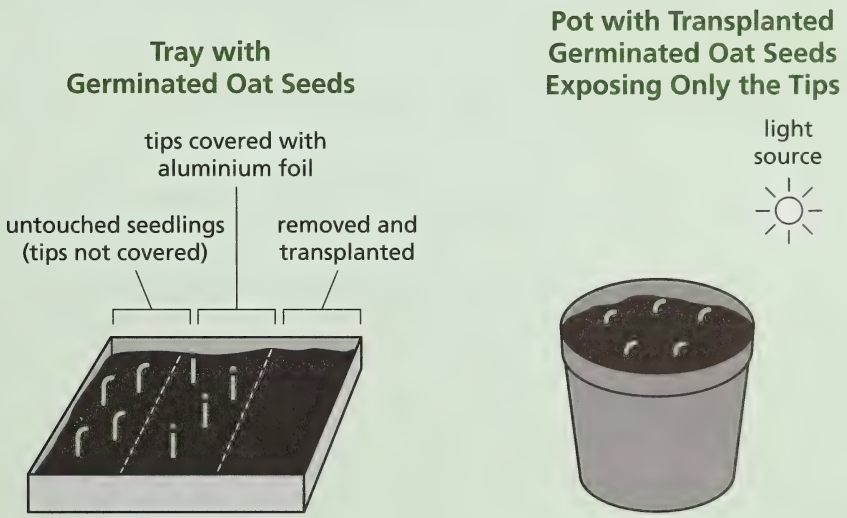



b. **Textbook question 2 of "Part 1: Forming Conclusions," p. 325**

2. The stem of each seed grew in a direction opposite to the pull of gravity, and the root of each seed grew in the same direction as the pull of gravity. Since the seeds were germinated in the dark, light should not have had an effect on the growth of the stems and roots.

8. a. **Textbook questions 1 and 2 of "Part 2: Analyzing and Interpreting," p. 325**

1. Your diagram should be similar to the following.



2. Your completed chart should be similar to the following.

| Growth Condition | Observation of Tropism | Explanation for the Observation |
|---|---|---|
| control group | The plants bent towards the light source. | The tip of the plant responds to the light source and is responsible for the resulting bending of the plant. |
| seedlings covered in soil exposing only the tip | The plants grew and bent towards the light source. | The tip of the plant responds to the light source and is responsible for resulting bending of the plant. |
| seedlings' tips covered with aluminum foil | The plants grew straight up with no bending towards the light source. | The tips of the plant were covered and could not respond to the light source. |

b. **Textbook question 3 of "Part 2: Forming Conclusions," p. 325**

3. The phototropic response is initiated in the tips of the seedlings.

c. **Textbook question 4 of "Part 2: Extending," p. 325**

4. You should have observed that the bending occurred part way down the stem. The plants that were covered in soil up to the tips bent only as the plant grew out of the soil. This is similar to what Charles and Francis Darwin observed.

9. a. The scientists who studied phototropism were

- Charles Darwin and his son Francis, who asked "Which part of the plant detects and responds to the phototropic stimulus?"
- Peter Boysen-Jensen, who asked "What is the signal that initiates the phototropic response?"
- F. W. Went, who asked "What specific substance is responsible for initiating the phototropic response?"

b. Charles and Francis Darwin experimented by covering the tip, removing the tip, and covering the base of the stem. They found that if the tip was covered or removed, no bending occurred. They also found that if the base was covered, bending still occurred. From this they concluded that the tip was somehow communicating with the cells in the area of bending.

   Peter Boysen-Jensen first cut off the tips of grass seedlings, covered the stump with gelatin, and replace the tips. He found that phototropism continued normally and that the gelatin did not interfere. He then followed the same procedure using a thin slice of mineral mica instead of gelatin. He noticed no phototropism in this experiment. From this, he concluded that whatever was responsible for communicating stimulus information from the tip was able to diffuse through the gelatin but not through the mica. He suggested some chemical must move from the tip to the area of bending.

   F. W. Went searched for and was able to isolate the chemical responsible for the bending stimulus—auxin.

10. Auxin is responsible for the stimulus for phototropism. Auxin is classified as a hormone.

11. Scientists believe that starch grains in specialized cells in plant roots are indicators of gravity. They believe that starch grains work by always moving to the bottom of the specialized cell depending on what position the cell is in.

12. Touch, temperature, chemicals, and water are four response mechanisms, other than phototropism and gravitropism, that plants respond to.

13. Some flowering plants flower only after a period of long nights of darkness. Examples include chrysanthemums, poinsettias, and Christmas cactus. Other plants need long periods of light to flower. Examples are coneflowers, lettuce, spinach, and potatoes. Others, like tomatoes, strawberries, and corn, will flower regardless of the length of darkness or light.

14. **Textbook questions 1, 2, and 3 of "Career Profile," p. 329**

    1. The ability to work on a team is important for research scientists because they often work with other scientists on a particular project. Often, research scientists study very specialized areas and need to be able to share information with other scientists.

    2. Answers will vary. You may be interested in crop research or the effects of climate change on plants. Other areas mentioned include the effects of radiation on plant growth and increasing crop production to help feed the poor.

    3. Answers will vary. Areas of interest may be in question 2 or you may wish to check the Internet for other areas of plant research.

15. **Textbook questions 1, 2, 3, 6, and 8 of "Check and Reflect" p. 328**

1. Tropism is the directional response of a plant to various stimuli and control mechanisms to ensure the survival of the plant.

2. Positive phototropism is the growth of the plant stem toward the direction of the light source. Negative gravitropism is the growth of the plant stem against the force of gravity.

3. Phototropism ensures that the plant receives enough sunlight for photosynthesis. Gravitropism ensures that the roots of the plant grow into soil where they can obtain water, minerals, and provide a solid attachment for the plant.

6. Tropisms are the plant's control mechanisms because the way in which the plant responds to stimuli determines how the plant develops.

8. Uses of synthetic plant hormones include the ripening of fruits and vegetables, the reduction of the growth rate of potted plants in nurseries and green houses, and the discouraging of the growth of weeds in crops without affecting crop growth.

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# Conclusion

In this section you described plants as multicellular organisms with specialized structures at the cellular, tissue, and system levels. You identified the mechanisms of transport, gas exchange, and environmental response in multicellular plants.

You discovered that the cohesion and adhesion properties of water, osmosis, pressure differences, and transpiration pull all help move water and sugars throughout plants. Do you now have a better understanding as to how 25-m to 100-m tall trees get water to their uppermost leaves?

The huge cedar trees in the temperate rain forest of British Columbia and the giant sequoias in California most often leave people in awe. If you ever have the opportunity to see these great specimens up close, you will be amazed. Just imagine the volume of water and nutrients that move up and down these trees.

# Module Summary

In this module you examined how cell structures and organelles function to carry out the life processes in living systems. You discovered how technological advancements have improved people's understanding of cell structure and function. You then applied this understanding of life processes at the cellular level to multicellular organisms.

In Section 1 you studied microscopy and the emergence of the cell theory. You traced the development of the cell theory and described how advancements in cell structure and function are a direct result of developments in microscope technology.

In Section 2 you identified the various organelles of plant and animal cells and described how these organelles carry out the functions necessary for the cell to survive.

In Section 3 you focused on plants as multicellular organisms with specialized structures at the cellular, tissue, and system levels. You examined the mechanisms of transport, gas exchange, and environmental responses in multicellular plants.

You performed a number of activities and investigations relating to microscope use, identifying cell structures, and analyzing cell efficiency. You also performed activities and investigations that led to an understanding of mechanisms of transport, gas exchange, and environmental response in plants.

You should now have a good understanding of cell structure, plant structure, and some of the environmental effects on plant growth. Plant research now involves plant response to radiation, improved yield and drought resistance through genetically modified seed, and hormone use in weed control.

## Module Review

Turn to page 333 of the textbook and scan the items listed in "Key Concepts" and "Learnings" for a review of the things you have been presented in this module. Then complete the following questions. If necessary, go back and read over the parts of this module as you answer the questions.

1. Define the following terms:

   - *cohesion*
   - *experimental control*
   - *plasmolysis*
   - *turgor pressure*

2. Answer the following Unit Review questions on pages 334 to 336 of the textbook.

   a. questions 3, 4, 7, 10, 13, 16, 18, 20, 22, 28, 29, 31, and 34 of "Knowledge"
   b. questions 39, 43, 51, 53, and 55 of "Applications"

Check your answers with those on pages 150 to 152.

## Suggested Answers

1. *Cohesion* is the attraction of individual molecules of the same kind to each other.

   An *experimental control* is an experimental set-up that includes all the conditions of the experiment, except that the manipulated variable is not changed from its normal conditions.

   *Plasmolysis* is the shrinking of the cytoplasm and plasma membrane away from the cell wall due to the flow of water from the inside of the cell to the outside of the cell.

   *Turgor pressure* is the pressure exerted against a cell wall by water that has entered the cell through osmosis.

2. a. **Textbook questions 3, 4, 7, 10, 13, 16, 18, 20, 22, 28, 29, 31, and 34 of "Knowledge," pp. 334 and 335**

   3. The problem associated with early lens technology was that images were blurry. This problem was overcome by using an achromatic lens to control the halo formed around the image.

   4. Francesco Redi's experiment was a controlled experiment because he manipulated the access of flies to the meat (controlled variable) in order to see the development of maggots in the meat (responding variable). He held all other variables, such as type and amount of meat and type of container, constant.

   7. Resolving power is the ability of a microscope to allow you to distinguish between two structures that are very close together. The wavelength of light limits the resolving power of a light microscope.

   10. An advantage of staining cells is that it allows you to see parts of the specimen more clearly. A disadvantage is that the cells are no longer living when stained.

   13. An open system is one that can exchange energy and matter with its surrounding environment. A cell is considered to be an open system because it takes in nutrients, water, and energy from its environment and outputs wastes. It also exchanges gases with its environment.

   16. Cell structures visible through a light microscope are the nucleus cytoplasm, cell membrane, cell wall, and chloroplasts.

   18. Cells must be able to take in nutrients, remove wastes, exchange gases, grow, and respond to stimuli.

20. Concentration gradient refers to the difference in proportions of solute and solvent in two areas. If there is a permeable membrane between the two areas, the solvent will diffuse across the membrane until the concentration of the solution is the same on each side. If the membrane is semi-permeable and only water can cross the membrane, water will pass through the membrane by osmosis until the two solutions are in equilibrium.

22. A vesicle is a sac that forms from a section of membrane that pinches off to surround a particle. In endocytosis, a vesicle forms around a particle and pinches off to encompass the particle to the interior of the cell. In exocytosis, the vesicle surrounds the particle and moves to the cell membrane where it fuses with it. The vesicle then ruptures and releases its contents to the outside of the cell.

28. Three main types of plant tissue are dermal tissue, ground tissue, and vascular tissue. Dermal tissue is responsible for exchange of matter and gases with the environment. Ground tissue provides support, stores food and water, and performs photosynthesis depending on the location of the tissue. Vascular tissue moves materials throughout the plant with xylem and phloem. Xylem moves water and dissolved minerals from the roots to other parts of the plant, and phloem moves sugars and water from the leaves to the rest of the plant.

29. Light and chlorophyll are not considered to be reactants in photosynthesis because they are not used up or produced.

31. Transpiration is the process of water leaving the plant through the stomata. Transpiration creates an upward draw on water and minerals from the roots due to the cohesion of water.

34. Xylem and phloem are the same in that they are both transport mechanisms for the plant. Also, both xylem and phloem are made up of many cells. They are different in that xylem cells are dead, whereas phloem cells are living. Also, xylem carries water and minerals from the roots to other parts of the plant, whereas phloem carries sugar and water from the leaves to other parts of the plant.

b. **Textbook questions 39, 43, 51, 53, and 55 of "Applications," pp. 335 and 336**

39. $$\text{diameter of 1 protist} = \frac{4800\ \mu\text{m}}{16}$$
$$= 300\ \mu\text{m}$$

The diameter of 1 protist is 300 μm.

43. The strawberries are covered with juice because the sugar creates a higher solute concentration on the outside of the strawberry cells. This causes water to move out of the cells by osmosis. The water then mixes with the sugar to make the juice.

51. During plasmolysis in plant cells, water leaves the cell through osmosis. The central vacuole shrinks and the cell membrane and cytoplasm draw away from the cell wall. This reduces the turgor pressure that the cell wall had and reduces the strength and support of the entire plant. (The plant wilts.) This process can be reversed by adding water to the soil around the plant so the root system can absorb water and transfer it to the rest of the plant. When the cells absorb water again, they become turgid and the entire plant becomes firm again (assuming that the time of lack of water is not so long that the plant dies or is too weak to rejuvenate).

53. Agree. During the day, plants perform both photosynthesis and respiration. Respiration uses oxygen and releases carbon dioxide. Photosynthesis uses carbon dioxide so there is very little net carbon dioxide released to the air. At night, plants do not perform photosynthesis, but they still perform respiration. Therefore, like animals, plants use oxygen and release carbon dioxide at night.

55. It is important for a plant to remain turgid because this is what keeps it upright and able to get the maximum amount of sunlight for photosynthesis. Pea plants respond to touch. They have tendrils that coil around nearby objects for additional support.

# SCIENCE 10

*Energy and Matter in Chemical Change*

*Energy Flow in Technological Systems*

*Cycling Matter in Living Systems*

*Energy Flow in Global Systems*

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